

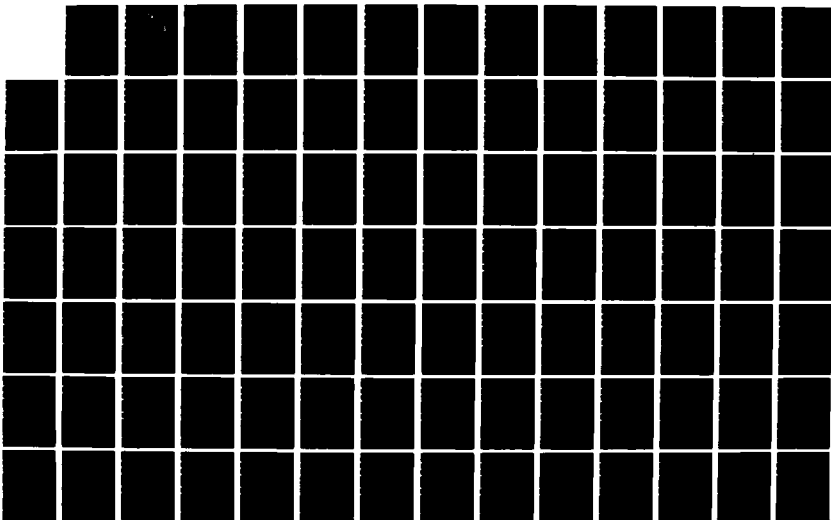
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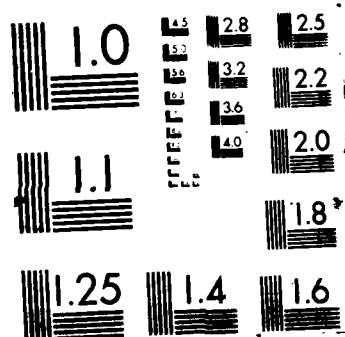
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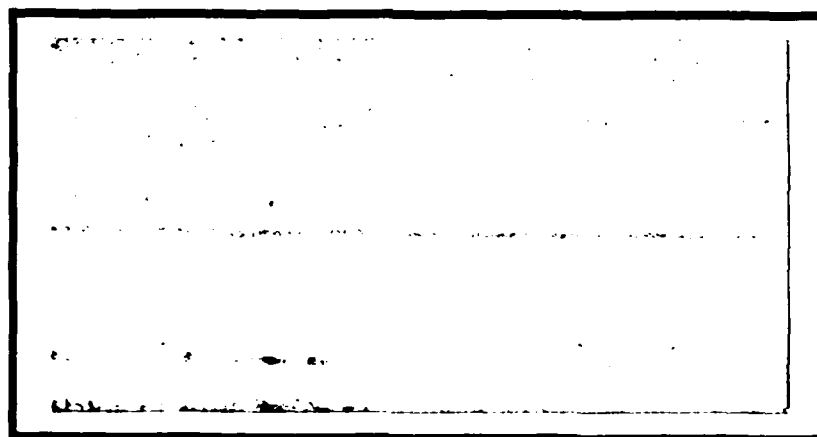




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A COMPARISON OF TRADITIONAL METHODS  
VERSUS LABOR STANDARDS IN THE  
PRICING OF DEFENSE SYSTEMS CONTRACTS

THESIS

Steven A. Marcy  
Captain, USAF

AFIT/GLM/LSM/87S-44

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AFIT/GLM/LSM/87S-44

**A COMPARISON OF TRADITIONAL METHODS VERSUS  
LABOR STANDARDS IN THE PRICING OF  
DEFENSE SYSTEMS CONTRACTS**

**THESIS**

**Presented to the Faculty of the School of Systems and Logistics  
of the Air Force Institute of Technology  
Air University  
In Partial Fulfillment of the  
Requirements for the Degree of  
Master of Science in Logistics Management**

**Steven A. Marcy, B.S.  
Captain, USAF**

**September 1987**

**Approved for public release; distribution unlimited**

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Steven A. Marcy

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Abstract

In recent years, reports by the media of cost overruns, overpriced spare parts, waste, and fraud have caused Congress and the public to doubt the ability of the DoD and the defense aerospace industry to control defense systems' costs. Valid or not, that perception has lead to statutory provisions ~~that~~ now require defense contractors to submit labor performance data, as well as cost and pricing data, with defense system proposals. Air Force Systems Command (AFSC) policy further requires the use of labor performance data, by both government and contractor personnel, to price and negotiate defense system contracts. Studies indicate that effective use of labor performance data, from a defense contractor's work measurement system, can result in more reasonable cost estimates, particularly in the case of sole source contracts.

The labor performance data referred to here is a part of what is commonly known as "work measurement". This study examined the evolving application of work measurement in the acquisition of defense systems. The study investigated the value of work measurement programs and explored techniques for using labor performance data in pricing defense contracts. The study also compared this pricing technique with more traditional methods. As the

implementation of this idea has stirred some controversy,  
the research also examines the issues that have arisen.

A COMPARISON OF TRADITIONAL METHODS  
VERSUS LABOR STANDARDS IN THE PRICING OF  
DEFENSE SYSTEMS CONTRACTS

I. Introduction

A. General Issue

Criticism of Government mismanagement of defense acquisition programs has been widespread and raises serious questions about the DoD's ability to control procurement costs. Demonstration of increased defense industry productivity and efficiency, combined with better control and estimates of costs is vital to repair eroding public and Congressional support of military spending. The United States Air Force (USAF) and Congress are requiring that defense contractors implement or upgrade work measurement systems and use labor standards for pricing/negotiating defense systems acquisitions. These actions are the result of the defense industry's failure to correct relatively low levels of manufacturing productivity/efficiency, as well as the DoD's ineffective control and estimates of costs.

## B. Specific Issue

Air Force Systems Command (AFSC) policy states that Work Measurement (WM) data, when available, be used to price contracts [28]. The fiscal year (FY) 1987 Defense Authorization Act, Section 943, requires that defense contractors maintain and provide cost and pricing records to the Government for pricing and negotiation of defense system acquisition contracts [37].

Implementation of policy and legislation has not been without problems and controversy. The use of labor standards to price and negotiate defense system contracts has not been wide spread or uniform, neither among the services nor within a given service [37]. AFSC officials have acknowledged that the value and techniques of applying work measurement data to the pricing and negotiation of contracts are not fully understood by government personnel. Therefore, because this pricing technique is relatively new, many government pricing personnel require training on the concepts of work measurement and the use of labor standards in pricing defense system contracts.

The defense industry continues to object to some of the requirements of recent legislation and service policies. Reasons cited for the objections include: the burden caused by reporting and supplying data to the Government; the exposure to further DoD micromanagement of their operations; and, the costs that may outweigh the benefits of these efforts [47].

### C. Research Objectives

The objectives of this research were threefold:

1. To update the literature on the application of labor standards to pricing defense systems contracts.
2. To compare the use of labor standards with the traditional methods for pricing direct manufacturing labor hours for defense systems contracts.
3. To identify the key issues surrounding the application of labor standards to the pricing of defense systems contracts.

This research should also provide military service acquisition managers an understanding of the concepts of work measurement and methods of application to pricing. A number of questions were used during interviews to aid the research of the above objectives.

### D. Research Questions

The following questions guided the literature search and the interviews conducted for this research. The interview guide in Appendix A was used to aid the researcher and ensure a consistent format for conducting the interviews.

1. What is the background of Government legislation and policies requiring the use of labor standards in pricing/negotiating defense system contracts?
2. How are labor standards used to price defense systems acquisitions?
3. What are the advantages of using labor standards to estimate costs as compared to more traditional methods?



4. What are the limitations of this technique?
5. What are the key issues surrounding the application of labor standards in pricing defense systems contracts?
6. Is training for cost and pricing personnel available and adequate?

#### E. Scope of Thesis

This study reviewed the concepts and analytical techniques of using labor standards to price defense systems contracts. It also compared these techniques with more traditional pricing methods and examined key issues associated with their application, including those issues concerning legislation and the use of labor standard data in government contract pricing. Finally, recommendations are presented for future research topics.

Air Force Systems Command (AFSC) leads the DoD in encouraging the implementation of MIL-STD-1567A and the use of labor standards in the pricing and negotiation of defense systems contracts [29]. Aeronautical Systems Division (ASD) is the largest buying division of AFSC and typically gets over half of the Command's budget. Air Force Contract Management Division (AFCMD), also a division of AFSC, commands the Air Force Plant Representative Offices (AFPRO's) located at different contractors' facilities across the nation. These organizations have led government efforts to establish effective contractor work measurement

systems to lower the costs of defense programs. Therefore, the sources for much of the research data and interviews were from these organizations.

#### F. Methodology

The research data were collected by means of a literature search, as well as telephone and individual interviews, conducted with government personnel from HQ AFSC and its divisions: Air Force Contract Management Division (AFCMD) and Aeronautical Systems Division (ASD). Government representatives were asked about Government legislation and policies, key issues, and the use of labor standards for pricing in comparison with traditional techniques. Personal interviews were conducted when possible, otherwise telephone interviews were used. According to Dominowski [16], the personal interviewing technique provides for more complete responses with less error in recording responses on the part of the interviewer as compared with other interviewing techniques. The telephone interviewing technique is considered to be the next most reliable technique for recording complete and accurate responses [16:185].

A literature review of industry white papers and journal articles on key issues was used to gain an understanding of the views of industry which often oppose those of the Government. Since this researcher is

currently a full time student the views are intended to be unbiased.

G. Definitions

The definitions of key operational terms in Appendix B should help the reader understand the discussions on work measurement concepts and the application of labor standards to defense system contracts. A majority of the terms were paraphrased from the literature reviewed.

## II. Background

A 1980 General Accounting Office (GAO) report to the Congress stated that the rising cost of defense weapon systems has resulted in the acquisition of fewer units of equipment than needed by the armed services which has adversely affected combat readiness [51:i]. Reports of large overruns and cost growth on many military programs in recent years, whether accurate or not, have aroused severe criticism by the media and are the topic of continued debate in the Congress.

John T. Correl, Editor in Chief of Air Force Magazine, stated that stories of "ridiculously" priced spare parts for military systems beginning in 1983, and revelations about falsified claims and improper charges by defense contractors in 1985, have further caused a majority of U.S. citizens to believe that the Government is being "cheated left and right" in military procurements [7:68]. Valid or not, that perception has threatened the revitalization of our national defense. At issue is the integrity of the defense industry and the ability of the DoD to manage these acquisitions effectively. Misunderstanding of government procurement and loss of public confidence have led to the enactment of statutory provisions and DoD/Air Force policies requiring the use of labor standards in the pricing and negotiation of major defense system contracts.

The United States Air Force (USAF) was the first branch of service to implement a program aimed at improving productivity and cost control by defense contractors. Military Standard (MIL-STD) 1567 (USAF), issued 30 June 1975, was the vehicle for this effort [51:ii]. This standard established a contractual requirement for an integrated and disciplined work measurement system in defense contractors' manufacturing operations. The purpose of the standard was: "to persist in achieving increased discipline in contractors' work measurement programs with the objective of improved productivity and efficiency in contractor industrial operation" [51:iii]. Officials at Air Force Systems Command (AFSC) stated that work measurement was one of two means necessary to obtain maximum efficiency with a given level of manpower resources; the other was the upgrade of facilities through the use of new technology [17:22]. Work measurement is a management effort where-as programs such as TECHMOD typically require large capital investments in equipment. The intent in using MIL-STD-1567 was to reduce in-plant costs, thereby reducing the costs of major weapon systems.

The implementation of MIL-STD-1567 (USAF) was the result of several studies of defense industry productivity and defense systems costs in the early 1970's. In 1972, the Sagamore study found that 45 percent of the time charged against the production of aircraft number 1000 was

unproductive [27:15]. This finding refers to the assumption in the defense aerospace industry that, with production of aircraft 1000, operations should be 100 percent efficient. In other words, by unit 1000, the contractor should have been able to remove all unproductive and unnecessary operations.

Subsequently, the Air Force conducted the Project Acquisition Cost Evaluation (ACE) study which was completed in mid 1973. The findings, as related by a 1980 GAO report, stated:

"Manufacturing labor contributes a sizeable portion of the total direct costs on typical weapon system production contracts. It is believed that a significant portion of the current labor cost is nonproductive because of manufacturing inefficiencies." [51:5]

The report further concluded:

"Effective work measurement programs throughout the defense industry would identify areas of low efficiency, improve work methods, and provide realistic productivity goals; thus contributing to significant cost reduction in the acquisition of defense systems." [51:5]

Prior surveys supported the Project ACE conclusions. An Air Force Contract Management Division (AFCMD) study of Air Force contractor plants showed that most had work measurement systems and labor standards but that: 1) they were poorly conceived and developed, 2) they were not applied in accordance with the intent or objectives of labor standards in some instances, 3) audit trails were practically nonexistent, and 4) data were not used to develop budgets or price proposals [51:5].

After several revisions and much dialogue with industry and professional people, the standard was published without the complete concurrence of industry. Overall, the Air Force advocated the use of MIL-STD-1567 (USAF) for the following three reasons: 1) industry initiatives had proven to be inadequate, 2) a savings potential of 10 percent to 20 percent of direct labor costs measured compared favorably with administrative costs of 1 percent to 4 percent of the direct labor measured, and 3) public support for defense would be enhanced if effective cost controls were demonstrated [27:16].

When MIL-STD-1567 (USAF) was introduced, industry characterized the approach as a "deterrent to free enterprise", "galloping socialism", and a "cost prohibitive-administrative monster" [3:14]. The prevalent attitude of industry in 1975 was reflected by the following statement, "The question is not the adequacy of the proposed MIL-STD-1567 (USAF). The question is whether any customer, including the Government, has the right to coerce private industry by a system of checks and balances on their internal management practices" [3:14]. Industry believes contractors should establish their own means of improving efficiency and reducing costs. However, the primary argument presented by industry concerned the documentation and reporting of data required by the standard. The documentation and reporting requirements were believed to be

more costly than as stated by the Air Force. It was also believed that the requirements would perpetuate a highly bureaucratic system and further expose contractor operations to DoD micromanagement [22:18].

The 1980's brought not only new hardware for the services, but scathing reports of cost mismanagement as well. Disclosures of \$318 toilet pans and \$7,622 coffee brewers by the media raised serious questions and criticism of the DoD's ability to control costs in their procurements [53:12]. The obvious question these reports raised in the minds of U.S. taxpayers was, "How can the DoD control the costs of its million and billion dollar programs when it can't control the costs of these ordinary items?"

In addition to the reports of DoD mismanagement, defense contractors continued to resist Air Force efforts to implement MIL-STD-1567 (USAF). This led the Air Force to release MIL-STD-1567A, a revised and more comprehensive military standard covering contractor work measurement systems, on 11 March 1983 [47].

Air Force Systems Command (AFSC) then established policy regarding the use of labor standards in contract pricing, negotiation, and management in August 1984 (Appendix C) [29]. This policy states that defense contractors must use labor standards when available and consistent with recognized cost accounting methods to: 1) develop budgets, plans, and schedules; 2) form the basis



for pricing and negotiations; and 3) baseline performance. This policy also states that Government representatives must use labor standards to price, negotiate, and monitor contracts [29].

On 8 January 1985, the Joint Logistics Commanders (JLC) signed an agreement supporting MIL-STD-1567A as an essential weapon in the DoD's cost reduction arsenal [30]. This meant that for the first time the standard would be used by all services to reduce costs and improve productivity. The JLC agreement was the first step in a cooperative effort to ensure wide and consistent application of MIL-STD-1567A. Yet, despite these actions contractors continued to resist the use of labor standards to the best of their ability.

By early 1985, Congress had begun introducing legislation addressing the defense acquisition process. Title IX, Procurement Policy Reform and Other Procurement Matters, of the 1986 DoD Authorization Act, (Section 912) specifically addressed the areas of:

- false claims, debarments, burden of proof and related matters;
- employment of Government procurement personnel with defense contractors and;
- defense contractor recording and maintenance of cost, pricing, and labor efficiency data [49:104-114].

This amendment directs DoD agencies to collect labor, material, subcontracts, overhead, profit and general and

administrative cost data for contracts of \$100,000 or more from both prime and associate contractors [36]. In particular, the amendment insisted labor costs were to be compiled using "current industrial engineered standard hours for the work proposed" [2:1]. It was clear the Congress intended to become more involved in the DoD's management of acquisitions.

In an attempt to improve DoD cost estimating and to give Government officials the ability to challenge contractor costs, the Congress directed the Secretary of Defense to present major defense acquisition programs, marked for "Should Cost" analysis, to the Congress (Appendix D). In constructing the language of the "Should Cost" Amendment, the House and Senate conferees decided to allow the Department of Defense to assign its resources where they would provide the most significant return, but also ensure Congress that it had adequate oversight of their use [49:3].

A Should Cost analysis conducted by Government representatives determines what a contractor's production costs ought to be. The Should Cost approach challenges the necessity and efficiency of past (actual) costs before applying them as a base to estimate future costs. The primary objective of a Should Cost analysis is to estimate future costs anticipating the greatest manufacturing efficiency attainable by the contractor. The Army's Should Cost Guide states that the intent of the Government is not

to tell the contractor how to run his business although production inefficiencies may have been identified. Instead, the Government presents the findings to the contractor and makes it clear that the taxpayers' money will not be paid out for those demonstrated inefficiencies [34:41].

The Should Cost technique is especially useful for, but not limited to, noncompetitive, sole-source contract negotiations. Noncompetitive, sole-source contracts typically do not encourage stringent cost controls or productivity improvements. Using the Should Cost technique, the Government may negotiate a more reasonable contract price and encourage continued attention on improvements [6:238].

The defense industry's concerns about legislation contained in the 1986 DoD Authorization Act were represented by Mr Richard Engwall of the Westinghouse Manufacturing Systems and Technology Center and the Aerospace Industries Association. He stressed the industry's efficiency performance, saying:

"There is no major difference between commercial and aerospace industry performance except that most commercial industry companies achieve standard in a shorter period of elapsed time due to significantly greater production volumes and rates as well as more long term program stability. Furthermore, product and process technology/specifications are much less complex than in the defense industry." [2:2]

He also stated that work measurement "...adds little value to the product we manufacture and in many instances is being non-cost effectively imposed on us by the application of MIL-STD-1567A" [2:2]. Industry has further stated that continued emphasis on MIL-STD-1567A is inappropriate because:

1. Direct labor is a small percent of total cost and growing smaller.
2. Direct labor is already the most measured cost element.
3. Other cost reduction initiatives have more potential to include overhead reduction, producibility engineering and planning, low risk transition to production, Manufacturing Technology, Technology Modernization, quality improvement initiatives, work-in-process inventory reduction, and participative management programs [2:8].

For these reasons, the defense industry has continued to resist Government efforts to use labor standards in the pricing and negotiation of contracts.

Despite the objections of industry, concerns about the growing federal deficit and increasing cost of military products caused Congress to amend the FY87 Defense Authorization Act to assure Government access to/and the availability of cost and pricing records of defense contractors. Section 943, of the FY87 Defense Authorization Act requires defense contractors to retain all cost and price documentation if it has been developed and used for internal management operations [37]. Government

representatives may now use this data, as well, to monitor program progress and formulate pricing and negotiating positions for follow-on, spares, or new buys of similar defense products. The objective is to arrive at a fair and reasonable price but one that forces the defense contractor to remove as much of the inefficiency from the production operations as possible [47].

Defense industry comments, concerns and recommendations were addressed by Air Force officials at a February 1985 meeting of defense and Government personnel at Air Force Contract Management Division (AFCMD). While objecting to the above legislation, industry did concede that the basic intent of MIL-STD-1567A was good, but most contractors already had work measurement systems that met that intent. In other words, the imposition of legislation and MIL-STD-1567A was unnecessary and burdensome because the work measurement systems that already existed were aimed toward reducing costs and improving productivity [2:8].

To investigate these claims, Air Force Systems Command (AFSC) conducted a survey of defense/commercial work measurement systems and published the results in September 1986 [32]. The purpose of the survey was to develop a data base of defense and commercial industry work measurement information from which facts, trends, and emphasis could be determined. Questionnaires were distributed by AFCMD to twenty-three major defense contractors and sixteen

commercial companies. The commercial companies' products varied from automobiles and consumer appliances to light business jets and industrial tractors. The defense industry responses were grouped by industrial sectors - airframe, propulsion, and electronics with those not specifically identifiable to any one sector compiled in a "generic" category. Direct comparisons were made with similar commercial companies where appropriate [32:1].

Both commercial and defense companies indicated that the value of work measurement depends on how it is applied in the manufacturing environment. Both commercial and defense industries reported meeting the basic criteria of MIL-STD-1567A. Most of the companies considered labor performance reporting, variance analysis, and methods improvement to be the most important aspects of work measurement systems [32:5]. Feedback on the successes and difficulties (costs versus benefits) of work measurement system applications was, however, limited and remains a controversial issue.

The survey found that the manufacturing environments of defense contractors and commercial companies are different. The commercial company manufacturing environment lends itself to work measurement more so than that of defense contractors. The commercial companies report larger production runs and more stable product lines than defense contractors. Yet, the more detailed work measurement

systems are found at defense contractors' plants; not those of commercial companies. This is attributed to the differences between the Government and defense contractor relationship and the commercial buyer and seller environment as well as the application of MIL-STD-1567A to defense contracts [32].

The survey also found that the extent to which each individual company's management supports and promotes the use and application of the work measurement system determines how well the system improves productivity and reduces costs. Defense and commercial companies reported that the major obstacles to meeting standards are engineering changes, material delays or shortages, machine or tooling problems, and rework [33].

Yet, the survey results indicated that defense companies focus on "operator efficiency" rather than "factory" problems which are the responsibility of management. Though most defense companies claimed to be using labor standards information to estimate costs, many do not identify and quantify the realization factor elements which account for the variances from standard. Those that do often limit their tracking to "operator" rather than "factory" elements which are management's responsibility [33]. Chapter IV discusses this in more detail.

Headquarters Air Force Systems Command concluded from the survey that, while defense contractors have the elements

in place for effective work measurement systems, company management has not been using the visibility of the systems to reduce costs or improve productivity [33]. Defense contractors have established accurate labor standards and routinely track worker performance against them. However, the extent to which the data is used to improve "factory" productivity, estimate, budget and schedule does not appear to fully comply with AFSC policy.

This finding has, in part, led to the continued emphasis by AFSC for both government and contractor management personnel to use labor standards to price and negotiate contracts [33]. AFSC believes that by paying only for what the product "Should Cost" will defense contractors begin to use work measurement systems more effectively [47]. Inefficient operations will have to be scrutinized and corrected by defense contractors in the future or they will face decreased profits.

To promote consistency in labor performance reporting and to minimize the contract administration workload, AFSC developed a contractual data item description (DI-MISC-80295) [46]. Interservice coordination was obtained, in January of 1987, to ensure broad and uniform application across the defense industry [37].

The data item requires a specific format for reporting work measurement data because of the many types of systems used by defense contractors. It gives government personnel



better visibility into contract performance and provides consistent information for interpretation of progress. It also increases contractor accountability by providing information that can be used for pricing and negotiation positions for follow-on and spares buys. When available this data will also serve as a basis for pricing and negotiation positions for full-scale development (FSD) and initial production contracts [47].

An AFSC review of contracts meeting MIL-STD-1567A application criteria showed that while coverage is progressing, the use of labor standards in pricing and negotiating contracts is progressing much slower. Mr. Charles H. Hooper, Director of Manufacturing at Headquarters Air Force Systems Command, presented the findings of this review to the Aeronautical Systems Division Pricing Symposium on 17 June 1987 [37].

Mr. Hooper stated that 158 of 213 AFSC prime contracts, that met MIL-STD-1567A application criteria, were either covered in-full or by some tailored version. Figure 1 shows the growth in MIL-STD-1567A application to AFSC prime contracts since 1975. In addition, 215 subcontracts contain the MIL-STD-1567A requirements [37].

The break out of coverage by product division of AFSC is shown in Table I. Although application of MIL-STD-1567A shows impressive results, Mr. Hooper pointed out that AFSC has been less than successful in achieving the intent of

MIL-STD-1567A [37], especially in the area of pricing and negotiating using labor standards as brought out by the AFSC work measurement survey released September 1986 [32:8].

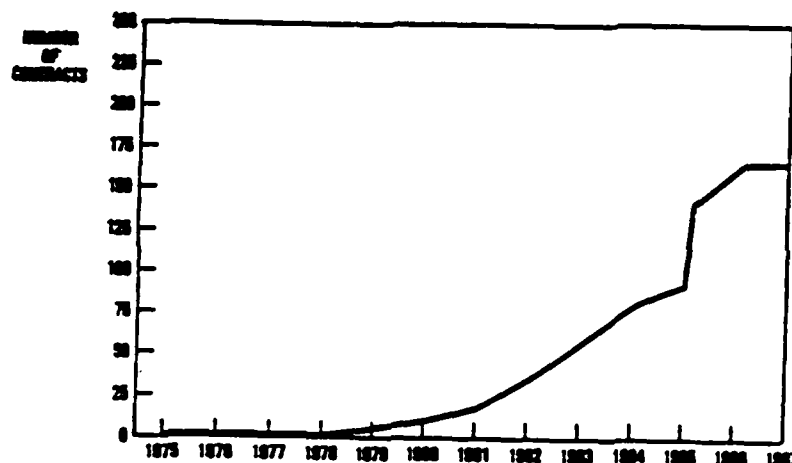


Figure 1. Growth of AFSC MIL-STD-1567/A Application [37]

Table I. Break-Out of MIL-STD-1567A Coverage by AFSC Product Division [37]

### 1987 APPLICATION STATUS\*

<u>AFSC DIV</u>	<u>AD</u>	<u>ASD</u>	<u>BMO</u>	<u>ESD</u>	<u>SD</u>	<u>TOTALS</u>
COVERAGE**	14	65	49	18	12	158
NO COVERAGE	0	43	0	10	2	55
FLOW-DOWN	22	147	24	11	11	215

\* CONTRACTS MEETING APPLICATION CRITERIA

\*\* 30% TAILORED

Since 1984, AFSC policy has been to use labor standards to price and negotiate contracts, but implementation of this policy has, so far, been slow. In 1985, 23 proposals were

submitted that used labor standards as a basis for estimates [37]. Of these, 7 were negotiated using labor standards and of these only 4 price negotiation memorandums (PNM's) actually detailed how these standards were used in the negotiations. In 1986, there were 23 proposals submitted with labor standards and 11 contracts were negotiated with labor standards. However, only 2 PNM's documented the use of standards in negotiations [37].

Summarizing the review, Mr. Hooper stated that labor standards have not been used effectively to price/negotiate contracts. The reasons cited were: 1) requests for proposal's (RFP's) were either vaguely written or did not direct the use of data, and 2) the value and techniques of pricing and negotiating using labor standards are not fully understood by government personnel. The findings of this AFSC review indicate the need for both immediate and long term training of government personnel in the principles of work measurement, as well as the detailed evaluation techniques of pricing using labor standards [37].

### III. Work Measurement Systems

#### A. Concepts

To understand the use of labor standards in the price analysis of defense products one should first understand the fundamentals of work measurement and the utility of Military-Standard (MIL-STD) 1567A. According to Dr. Richard Adams of the Directorate of Manufacturing at Aeronautical Systems Division (ASD), work measurements and the reporting of labor performance data should not be considered ends in themselves, but rather the means to more effective management and, thus, productivity improvements and cost reductions [1].

Typically, contractors who have demonstrated the ability to produce particular kinds of products are generally awarded new contracts on that basis. However, military products often require state-of-the-art manufacturing technology. Still, many of the operations required in the production of defense items will be similar or identical to those repeatedly performed on other products. The collection of this production information allows contractors to build data bases with which to monitor on-going operations as well as to estimate future performance.

Work measurement systems collect data on these operations, by tracking work hours and the production of work units, to determine the relationship between work performed and work hours expended. The 1980 GAO Work Measurement Report to the Congress stated;

"It would be folly for management to attempt to manage without some knowledge of the most efficient and effective manufacturing methods and how long it should take to perform work. Therefore, the relevant question concerning the application of work measurement as a management tool is not whether it should be used, but rather what type should be used and to what extent it should be applied." [51:1]

The GAO report also stated that the prime objectives of work measurement are increasing productivity and measurement of worker performance. Increasing productivity with work measurement systems does not mean, however, working the labor force harder, but rather more effectively. Modern work measurement is based upon the supposition that an individual's performance will improve if the individual knows what is expected of him/her. A worker also requires frequent feedback on past job performance in order to know how to improve [51:1].

The foundation of a work measurement system is the labor standard. A labor standard can be expressed as a time standard or as an output standard. A time standard is the amount of time it takes to produce one unit or complete one operation. An output standard is a production rate for a given unit produced by a certain production method. Time

standards, output standard or labor standards all mean the same thing and can be used interchangeably [8:5-35]. These standards are based on the rate of production an average worker should attain when working under normal conditions at a normal pace with adequate supervision [8:5-35].

A labor standards program may be based on contractor developed standards, standards developed by other companies, or standards used throughout an industry. Company standards may be considered proprietary information and not for use by other companies. For this reason, contractors may guard their work measurement data very closely [8:5-34].

There are five principal methods of establishing labor standards today: Time Studies, Work Sampling, Predetermined Time Systems, Standard Data, and Previous Experience. The Armed Services Procurement Manual (ASPM) states that the three most common types of work measurement systems are based on Time Studies, Work Sampling, and Predetermined Time Systems [8:5-34].

The Time Study method is accomplished in the following manner: 1) each job required in the production of a unit is broken down into its component tasks, 2) a particular method, for each element is identified and developed, 3) a number of employees must be selected and trained, 4) the operations are observed and timed (with a rating applied according to the abilities of the worker), 5) a mean average time for the job is determined from those observations, and

finally 6) allowances for personal fatigue and unavoidable delay are added in. The sum of these times provides a standard time for performing a given job. The selected number of workers for observation depends on the accuracy and confidence level required of the standard. The ASPM states that this method is very accurate; however, workers typically don't like to be observed and timed by management [8:5-34].

Work Sampling, according to the ASPM, also requires the observation of worker performance by an experienced industrial engineer. A large number of random, rather than continuous, observations is required to ensure reliability. This method is questionable for setting exact standards or evaluating methods because individual worker motions or elements of a work cycle are not timed. Instead, the entire operation or process is timed. This method is commonly used for: 1) determining job content, 2) assessing productive versus non-productive time, and 3) providing feedback to management and enabling workers to better use their time [8:5-34].

The Predetermined Time Systems technique is closely related to the Time Studies technique in that operations are continuously observed with job elements broken into basic human motions such as "reach", "grasp", "move", and "release". According to the ASPM, there are many commercially available programs that provide more accurate

standards than the other techniques just discussed. These programs use information, procedures and techniques common throughout an industry to set standards that can then be applied to a contractor's particular operations [8:5-35]. However, this technique requires precise measurement of job elements by experienced Industrial Engineers to maintain and build new standards. Therefore, it is usually inappropriate for complex tasks with a long production cycle time [8:5-35].

The Standard Data technique builds a table of established performance times for specific tasks. Contractors that use this technique build their own data base of standard times to accomplish highly repetitive and basic operations. Examples of standard data are: 1) the time required to drill holes, or 2) the time required to paint a certain square foot of surface [8:5-35].

A fifth technique for setting work measurement standards is the use of "previous experience". This technique develops time standards for present work using past performance records. Although inexpensive, unknown variables in past operations (such as unnecessary or inefficient operations) make it less reliable than the other techniques. It does not allow change in processes and is subject to interpretation and recording errors [51:25].

Work measurement systems track performance according to the standards, for the job(s) that were required to produce



the item, and the actual time required to complete work. Management uses the resulting data - the relationship of actual versus standard - to evaluate areas of low productivity for early identification of potential improvements in personnel, planning, scheduling, manufacturing, budgeting, performance evaluation, methods improvements and cost control [51:1].

Labor standards that are established using industrial engineering techniques are referred to as Type I labor standards. These include: Time Studies, Predetermined Time Systems, Work Sampling, and Standard Data. Those that are established based on estimates (such as historical data) or judgements are referred to as Type II labor standards.

The defense industry uses many variations of these five methods of work measurement but they provide essentially the same data. Air Force officials have not been concerned so much with the type of standards used by contractors as with the accuracy of the standards and the extent to which they are used to manage operations [47].

B. MIL-STD-1567A

The purpose of MIL-STD-1567A is to increase discipline in contractors' work measurement programs with the objective of improved productivity and efficiency in contractor industrial operations [11:iii]. The standard applies to major full scale development (FSD) acquisition programs over

\$100 million and production programs over \$20 million annually or \$100 million cumulatively. As a guide, it is also applicable to subcontracts over \$5 million annually or \$25 million cumulatively, when the standard is applied to a prime contract. MIL-STD-1567A requires that contractors have and use a documented, disciplined, integrated work measurement system in their manufacturing operations [11:4].

The general requirements are:

- a work measurement plan and supporting procedures;
- a clear designation of the organization and personnel responsible for executing the system;
- a plan to establish and maintain engineered labor standards of a known accuracy;
- a plan of continued improved work methods in connection with the established labor standards;
- a defined plan for use of labor standards as an input to budgeting, estimating, production, planning, and touch labor performance evaluation; and
- a plan to ensure that system data is corrected when labor standards are revised [11:4].

The following specific requirements are also stated in the standard, and if complied with by the contractor, define an "effective" work measurement program by the Air Force:

- Type I standards accurate to plus or minus 10% with 90% confidence (It was plus or minus 25% in the June 1975 release);
- 80% coverage of all categories of Touch Labor with Type I standards. Type I standards are to be established using a recognized technique to derive 90% of the normal time associated with the labor type;

- schedule for upgrading all Type II standards to Type I;
- time associated with personal fatigue and unavoidable delay to be included in labor standards;
- labor standard's relationship to price proposals;
- performance reports prepared at least weekly for each work center;
- written variance analysis for significant departures from standards; and
- audit program [11:5].

When the MIL-STD-1567 was first imposed, contractors objected to the coverage requirements stating they were unnecessary and exposed them to DoD micromanagement. The Air Force noted these concerns but insisted that work measurement programs must set objectives for reaching 80% coverage of Type I engineered standards for two reasons [47]. First, it is expected that 20% of the time standards will cover 80% of the direct labor hours. The second is that approximately 80% coverage of the direct labor hours appears to be a reasonable minimum to give credibility to and promote confidence in a work measurement program [27:16].

One of the continuing controversies concerning MIL-STD-1567A is the accuracy requirements. The Air Force has maintained that the key to an effective work measurement system is confidence in the standards. MIL-STD-1567A increased the requirement for the accuracy of engineered standards to plus or minus 10% (was plus or minus 25%) with

a confidence level of 90%. An audit requirement helps to assure system discipline.

There is no doubt that work measurement programs cost money but how much has also been a topic of considerable debate. There are costs associated with building, applying, and maintaining standards; developing reports; administering and operating the program; and auditing the system. In 1976, Air Force officials stated that a range of 1 to 4% of direct labor hours accurately represented the costs of conducting a work measurement program in conformance with MIL-STD-1567. For a program that must be established from scratch the costs were said to be as high as 3 to 7% of direct labor hours [27:15]. The 1986 AFSC work measurement survey summary reported that the average annual costs to implement and maintain a system, in conformance with MIL-STD-1567A, were about \$3 million for responding companies [32:8].

The magnitude of the savings potential, though, is largely judgmental and has been a topic of much debate. It has been estimated that there are potential savings of from 10 to 20% of the direct labor hours measured [27:16]. The 1980 GAO report estimated that one contractor improved his direct labor performance by 10 to 15% by converting Type II estimates to Type I engineered standards and saving, in the process, \$6 million [51:14].

There are many other benefits from a disciplined work measurement system. According to the 1980 GAO report, where work measurement systems have been implemented and conscientiously pursued, excess labor costs and lost time can be reduced and continued improvements made regularly [51:7]. Colonel Roger Alexander stated, in a research report for the Air War College, that with an effective work measurement system the contractor (and the government) can:

1. Gain visibility into labor inefficiencies at the level at which the problems occur.
2. Evaluate alternate manufacturing methods by comparing the labor time standards required to complete a task using one method with those required using an alternate method.
3. Use the labor time standard as the ultimate performance objective.
4. Gain pricing and negotiation insight by using performance against labor time standards as a tool to quantify past performance and forecast future improvements. [2:4]

This last point serves as the primary focus for the remainder of this research effort.

#### IV. The Use of Labor Standards in Pricing Direct Manufacturing Labor

The Department of Defense (DoD) acquisition process often results in a sole source environment which does not encourage stringent controls [6:238]. Critics of sole source contracting have argued that increased competition is the only means of controlling costs. Mr. William Chamberlain, Chief of Pricing at Air Force Contract Management Division (AFCMD), stated that if the DoD can't rely on competition to control costs, good productivity and manufacturing efficiency also cannot be guaranteed. Sole source contractors are motivated by total revenue and, therefore, the more money that passes through the company, the more justification there is for company growth. Added revenue also means added profit, even though the actual profit percentage may not be as great. [6:238]

Government pricing personnel base estimates of future costs upon historical costs. Without competition actual costs may reflect unnecessary or inefficient operations. The "Should Cost" approach challenges the necessity and efficiency of past costs, but requires a large team of qualified personnel who are often hard to field [6:238]. However, through the use of good labor standards and an appropriate realization factor, the benefits of "Should Cost" analysis can be achieved with fewer personnel.

#### A. The Traditional Pricing Technique

The traditional cost estimating approach uses historical costs as the baseline for contract negotiations. Cost analysis of a contractor's proposal by a Government analyst consists of the review and evaluation of a contractor's cost and pricing data as well as of the judgmental factors applied to the projected estimated costs from the data [8:42]. This analysis is then used by the contracting officer who evaluates and reconciles the reports to establish the Government's initial negotiating position.

Cost and pricing data submitted in support of a proposal by the contractor are typically divided into cost elements of direct material, direct engineering labor, direct manufacturing labor, material overhead, engineering overhead, manufacturing overhead, general and administrative expenses, and profit. In many contracts, direct labor costs (engineering and manufacturing) often account for thirty-five to sixty percent of total costs [13:43]. Direct costs are usually the basis for allocating most of the indirect (overhead) costs. The Principles of Contract Pricing manual [13] states that manufacturing overhead costs can often be 150 percent or more of direct manufacturing labor costs. Engineering overhead rates are often even higher. General and administrative rates and profit rates are then traditionally loaded on successive application of these predetermined rates [13:43].

Any inefficient or unnecessary operations of a direct cost nature will be multiplied and cause a much greater price to the Government. For example, if a contractor has a manufacturing overhead rate of 150 percent of direct manufacturing labor costs and direct labor costs are overstated by \$100; then the total direct and indirect manufacturing costs would increase by \$250. If the general and administrative costs are applied at a rate of 10 percent of total manufacturing costs, then the total increased cost would be \$275. Finally, if profits were estimated at 10 percent of total cost, the estimated price to the Government would be \$302.50 more than it should be. No other element of cost has as much leverage in terms of return on analysis effort as direct labor costs.

However, in the past, the Government price analyst has only had sufficient information to challenge the validity of wage rates. Conversely, data to challenge the accuracy as well as the efficiency of the contractor's proposed manufacturing labor hours have been lacking [47]. Direct labor costs are the product of labor hours and labor wage rates. Figure 2 depicts how labor costs may be estimated from historical data.

A long-accepted method for estimating labor hours is to plot production units or lot releases on arithmetic log-log paper for observing production trends. This trend of contractor actual hours is then projected on the same log-



log paper to arrive at the anticipated labor hours [6:239]. This quantitative technique can be interchangeably called learning, improvement or experience curve theory. The learning curve concept has been used by government agencies since World War II to aid in the pricing of selected Government contracts.

The problem with the learning curve approach is that past uneconomical or inefficient practices by the contractor are a part of his actual costs. In using actual costs as a base for projecting future costs, inefficient practices by the contractor are then perpetuated rather than eliminated.

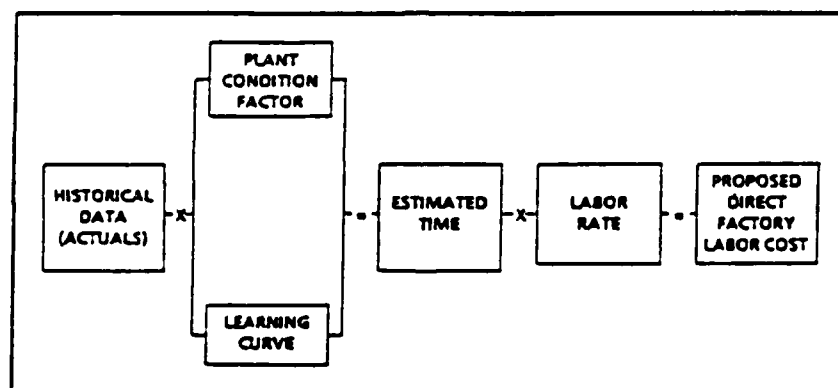


FIGURE 2. Using Historical Data to Estimate Labor Costs [8:5-34]

#### B. The Should Cost Concept

The 1986 DoD Authorization Act, Section 912, requires the performance of Should Cost analysis on selected major defense system programs and has presented a major management

challenge to those acquisition managers tasked with carrying out its requirements. The challenge has been for these managers to perform a Should Cost analysis in an efficient and effective manner, consistent with the intent of the legislation, while constrained by limited resources [53:19].

A Should Cost analysis uses an integrated team of Government contracting, engineering, manufacturing, audit and pricing specialists to conduct an in-depth review of all phases of the contractor's plant and operations to determine what a contractor's production costs ought to be [53:19]. The review examines the contractor's engineering and manufacturing operations, accounting procedures, cost estimating systems, purchasing procedures, make or buy decisions, organizational structure, and any other elements of cost and management control required for contract performance [34:1-14]. The Should Cost analysis considers all activity in a contractor's plant and is not limited to one product or program. The intent is to verify or challenge (if need be) the necessity and efficiency of past actual costs before applying them as a base to estimate future costs. The primary objective is to estimate future costs by anticipating the greatest manufacturing efficiency attainable [6:238]. The Should Cost findings support the Government's position that taxpayers' money will not be paid out for demonstrated inefficiencies [53:20].

Another benefit of the Should Cost analysis is that Government representatives can identify certain non-recurring costs or production start-up costs that should not be included in subsequent production contracts. These complex costs are often difficult to segregate and identify under traditional analysis techniques [53:22]. These non-recurring costs can be easily hidden by defense contractors, and the Government has probably paid for these on many contracts where no Should Cost analysis was performed.

Although the return on investment for this evaluation effort has been extremely high with numerous long-term efficiency improvements [6:238], there are several important limitations of a Should Cost analysis that may offset or reduce the benefits. To effectively challenge a contractor's costs, the Should Cost team must be well acquainted with every aspect of the contractor's operations and facilities. The only place this kind of assessment can take place is at the contractor's facility. Past Should Cost efforts have required from as few as eight persons to as many as eighty persons depending on the depth of analysis [53:24]. This means Government personnel may be away from their home base anywhere from several weeks to as many as five months [34:2-1]. The costs incurred by the Government for personnel salaries, travel, and lodging of a Should Cost team are significant. The costs to the contractor of supporting such an effort can also be immense. In addition

to the cost constraints, if circumstances preclude the team's having sufficient time to do a quality job, an Army document entitled "Should Cost Analysis Guide" recommends that the analysis not be done [34:2-2].

To achieve the benefits of a Should Cost analysis, the Government team must have an adequate number of experienced and skilled personnel. They must understand the manufacturing methodologies, the production plan and the production schedules of the contractor. They must be able to compare many historical records with actual production experience, identify hardware flow efficiencies, observe the reasonableness of direct-to-indirect personnel ratios, identify scheduling bottlenecks and equipment utilization problems [6:238]. Team members must perform individual data collection and analyses and be able to form independent conclusions. Without these trained personnel the contractor may quite properly question the validity of the entire process, which can produce flawed results. Therefore, due to the cost and the constraints in obtaining adequate resources, those acquisition managers tasked with carrying out a Should Cost analysis have been presented with a major challenge [53:24].

C. The Application of Work Measurement Data  
to Proposal Evaluations

Because the Government has been unable to always obtain such worthy resources as needed to perform Should Cost evaluations, another means of achieving the same results has been identified -- the use of labor standards for estimating direct manufacturing labor costs [6:239]. This tool can be used to provide the visibility of a Should Cost analysis but does not require the same resources.

Existing legislation requires defense contractors to submit cost and pricing data to the Government for contracts over \$100,000. This includes work measurement data when it has been used to build proposals [49].

Since no two contractors' work measurement data are the same, efforts by Government analysts to use this data have not been widespread. Contractual data item (DI-MISC-80295), now approved and supported by all the services, will promote the widespread and consistent use of labor standards through standardized reporting of labor performance data [47]. Air Force Systems Command (AFSC) expects a greater use of labor standards to price/negotiate contracts to result. Mr. Sydney Pope, Manufacturing Staff Officer at AFSC stated that the intent of the Government, in doing this, is to drive defense contractors to more efficient and productive operations by paying only for the contractor's efficient and necessary operations [47].

AFSC policy states that work measurement data, when available, will be used to price contracts (see Appendix C). Because this technique is new to many AFSC pricing personnel, training in the concepts of work measurement and methods of application is needed. To date no service school has offered a comprehensive course that would teach government price/cost analysts everything needed to complete an analysis of a contractor's proposal using labor standards [47].

As a result, Air Force Systems Command (AFSC) has tasked the Air Force Contract Management Division (AFCMD) to develop and teach a four day training course on "How to Apply Work Measurement (WM) Data in Proposal Evaluation." This course will be presented to AFCMD pricing and manufacturing personnel, as well as to the buying divisions' pricing/negotiating personnel during late fiscal year (FY) 1987 and, possibly, throughout FY88.

The availability of the FY88 courses is uncertain, at this time, because funding has not been approved [43]. If the FY88 courses are conducted, AFCMD anticipates instruction of the majority of pricers. Training for new personnel after the FY88 courses will be deferred back to the various service schools (such as the Air Force Institute of Technology) according to Mr Sydney Pope of AFSC [47].

The location and number of AFSC Product Division pricing personnel requiring training are shown in Figure 3.

There are about 325 pricing personnel in AFSC including the 109 pricers in the product divisions of AFSC [47].

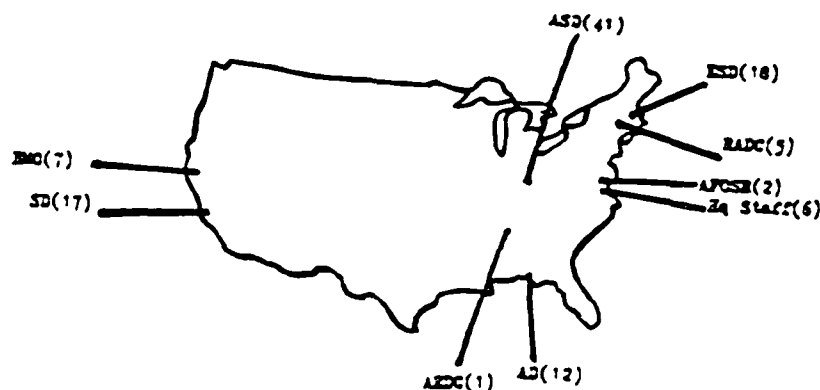


Figure 3. Location and Number of AFSC Pricing Personnel [47]

This discussion of the application of work measurement data will now focus more specifically on the use of labor standards as a pricing technique and then illustrate their use with an example.

#### 1. The Labor Standards Pricing Technique.

Good engineered labor standards and an effective variance analysis program form the basis of an effective work measurement system, which can be used not only to measure and improve efficiency, but to price and negotiate contracts, as well. If indirect expenses are allocated on the basis of factory labor hours, a review of the number of hours estimated for a job is especially important. As mentioned, any error in estimating the base labor costs will be compounded when allocating indirect expenses and profit.

Therefore, if labor standards are the basis for the labor estimate and other manufacturing effort is added to this known efficiency level, the Government can better measure the reasonableness of the additional manufacturing effort (indirect costs) as well as the direct labor costs.

To understand and evaluate estimated labor, one should first understand how much and when certain types of labor are used in the production life cycle. In the start-up phase of a program, the emphasis is on design and production engineering. The next phase, initial production, then emphasizes tooling and set-up efforts. With the transition into full production, machining and assembly represent the major percentage of labor. By the end of production, most of the work being done is assembly and testing labor. If there are changes made to the product, the mix of labor will fluctuate, as well, because each change may require new design, tooling and set-up efforts [47].

To use labor standard data from the contractor's work measurement program to estimate direct (or touch) manufacturing labor, there are two components that first must be analyzed. One is the standard itself, and the other is the realization factor (or variance from the standard). If the realization factor is being accepted by the contractor without question, then this is just another way of rationalizing or justifying actual hours expended. But, if the variance analysis program is being used as it should



be, then unreasonable variances are being carefully reviewed by the contractor to identify causes, and action is being taken to correct them [6:239].

a. Standard Hour Analysis.

Contractors rarely propose standard time [47]. Frequently, standard time cannot be achieved until production has reached maturity (recall that the average assumption in the aerospace sector concludes that the standard is achieved around unit 1000). Additionally, design, process, or program changes may interrupt production and further delay achieving standard. Most estimates are composed of standard time plus time allowed for below-standard worker performance due to inexperience as well as other factors that will be discussed later.

The Armed Services Pricing Manual (ASPM) directs government price analysts, with the help of government industrial engineers, to examine the elements that make up labor standards. The first element to be examined should be the leveled (also called normal) time, which is the time that a worker of average skill making an average effort under average conditions, normally spends on a specific operation or process. It does not contain allowances of any type [8:5-34].

The leveled time should be examined to determine if times are accurate by checking the number of time studies or

work samples used to build the standard. The actual number of studies or samples will depend on the type of work measurement technique used. According to the ASPM the three most commonly used techniques for determining leveled time for an operation are time study, predetermined leveled time, and work sampling [8:5-34].

Another component of labor standards that must be examined by the price analyst is the allowance for personal, fatigue and delay (PF&D) time. The ASPM suggests a personal allowance of 5 percent, a fatigue allowance of 5 percent, and a delay allowance of 5 percent for a combined PF&D allowance of 15 percent. The ASPM states that a reasonable combined PF&D allowance, under normal conditions, should be no greater than 20 percent [8:5-35]. Other literature suggests that allowances are very sensitive to the particular situation. Some work conditions may legitimately require allowances greater than 20 percent.

The personal allowance is built into the labor standard to allow the average operator the time to take care of such personal needs as a drink of water and the restroom. According to the ASPM, some contractors include rest periods for recovery from fatigue while others do not according to collective bargaining agreements with their unions. Lunch periods are not included in PF&D allowances. The Government accepts fatigue allowances when contractors show that personal allowances are insufficient for complete fatigue recovery [8:5-37].

The delay allowance is for unavoidable and predictable delays such as machine maintenance and minor repair, material replenishment and changes to work instructions. The ASPM states that the contractor should determine the kind and amount of delay by periodic studies. Avoidable delays are the result of mismanagement or poor skill or judgment and therefore should not be included. Unpredictable delays such as power failures, major machine breakdowns and interruptive acts of nature should also not be included in a delay allowance. Lost time resulting from unpredictable delays is usually treated as an indirect cost [8:5-37].

The last allowance included as part of the labor standard is the special allowance. Typical delays included in this allowance are such unavoidable delays as cleaning machines or sweeping the work area if these duties are regular assignments of the direct factory laborers to which the standard applies [8:5-38].

The sum of leveled (or normal) time, the PF&D allowance and the special allowance is standard time as is shown by Figure 4. Standards that are built up this way are referred to as a Type I engineered standards. These Type I standard times may be shop, contractor or industry particular. However, the AFSC survey released September 1986 reported that few of these are totally "unique" and almost all utilize elements or operations that have been previously

developed [32:6]. Contractors accumulate work measurement data by departments using the following formula (or something similar):

Leveled time	+	Personal, fatigue and delay allowance	+	Special allowance	=	Standard time
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Figure 4. Standard Time Factors [8:5-36]

The ability of a contractor to establish (and the price analyst to subsequently use) Type I standards depends upon the progress and timing of production. Mr. Sydney Pope of Air Force Systems Command offered the following examples. When a program is in its early stages (full scale development for instance), the design may change frequently. Production of the first few items may be piecemeal in accordance with prototype building and testing. Type I standards may be only a small portion of the unit/labor hour content. But because of the unstable nature of the design, processes and methods, a Should Cost analysis would not be appropriate according to Mr. Pope. As the program reaches early or pilot production, the contractor's industrial engineers are able to measure and define more of the operations to meet Type I standard criteria. However, Type I standards may only account for 20-30 percent of the standards at this point. The remainder of the standards are estimated Type II non-engineered standards. Taken together

these standards may be used as a basis for a Should Cost analysis. But if the Type II standards are not deemed reliable then this pricing technique may not be suitable [47].

As a program reaches mature production, MIL-STD-1567A requires that Type I engineered standards account for 90 percent of the normal time associated with a particular labor standard. Follow-on buys take advantage of this mature production because the design has stabilized and manufacturing resources have been set. Follow-on buys then present the best opportunity for a Should Cost analysis because the Government price analyst should have reliable standards on which to base the price estimate [47].

Government price analysts may also use standards to estimate costs for spares buys. The extent to which Type I standards are available for the analysis depends upon how it was last made. Type II standards may be required if there were technological changes or process and methods improvements since the spare item was last made. Type II standards may also be required if a contractor other than the one proposing previously produced the item [47].

b. Variance Analysis.

Once a reasonable estimate of standard hours is determined for an operation or process, other non-standard elements (or variances from the standard such as wrong parts, scrap, or weather delays) can be added to account for actual hours. The make-up of these elements will depend upon the contractor's particular accounting system and what is or is not included in the contractor's standards. The sum of these non-standard elements is called the variance from standard.

The sum of standard hours and the variance from standard is the actual time required by the contractor to perform a particular operation or process. This variance from standard is the second component that must be broken down and analyzed by Government representatives.

The ratio of actual time to standard time is then called the realization factor (or the performance index). A realization factor is built from analyzed performance data and is then used to project future performance. The key to the analysis of past performance or variance elements according to Mr. Pope, is the determination of which touch labor hours built into the realization factor are productive and recurring and which ones are non-productive and non-recurring [47]. By removing the non-productive and non-recurring hours a more reasonable realization factor can be applied to the proposed standard hours to arrive at a

"Should Take" time [47]. This Should Take time represents the time it would take the contractor to build the item using the most efficient operations possible.

Some contractors use efficiency factors rather than realization factors. An efficiency factor, the mathematical reciprocal of a realization factor, is derived by dividing standard time by actual time (and multiplying the result by 100 to produce a percentage). The ASPM uses the following example to illustrate this difference:

Suppose eight units should be produced in an eight-hour day (one standard hour per unit), but only six are produced. By dividing the six-hour standard time (the time it should have taken to produce six units) by the eight hours of actual time, an efficiency factor of 0.75 or 75 percent is calculated. A 75 percent efficiency factor is equal to a 133 percent realization factor. An efficiency factor of 75 percent means that the contractor is producing 75 percent of what they are supposed to produce in standard time [8:5-40].

Mr. Richard Engwall, Manager of Systems Planning, Analysis and Assurance at Westinghouse Electric Corporation, in a paper on realization factors of defense contractors, classified the elements of realization factors typical of defense contractors.

Figure 5 depicts how these categories of elements might vary and affect the value of the realization factor (or performance factor) throughout the life cycle of a program. The elements that make up each category of a realization factor depend upon the stage of production and the contractor's mode of operation. Mr. Engwall specified the

elements of variance from standard with respect to the first unit produced that were typical of defense contractors.

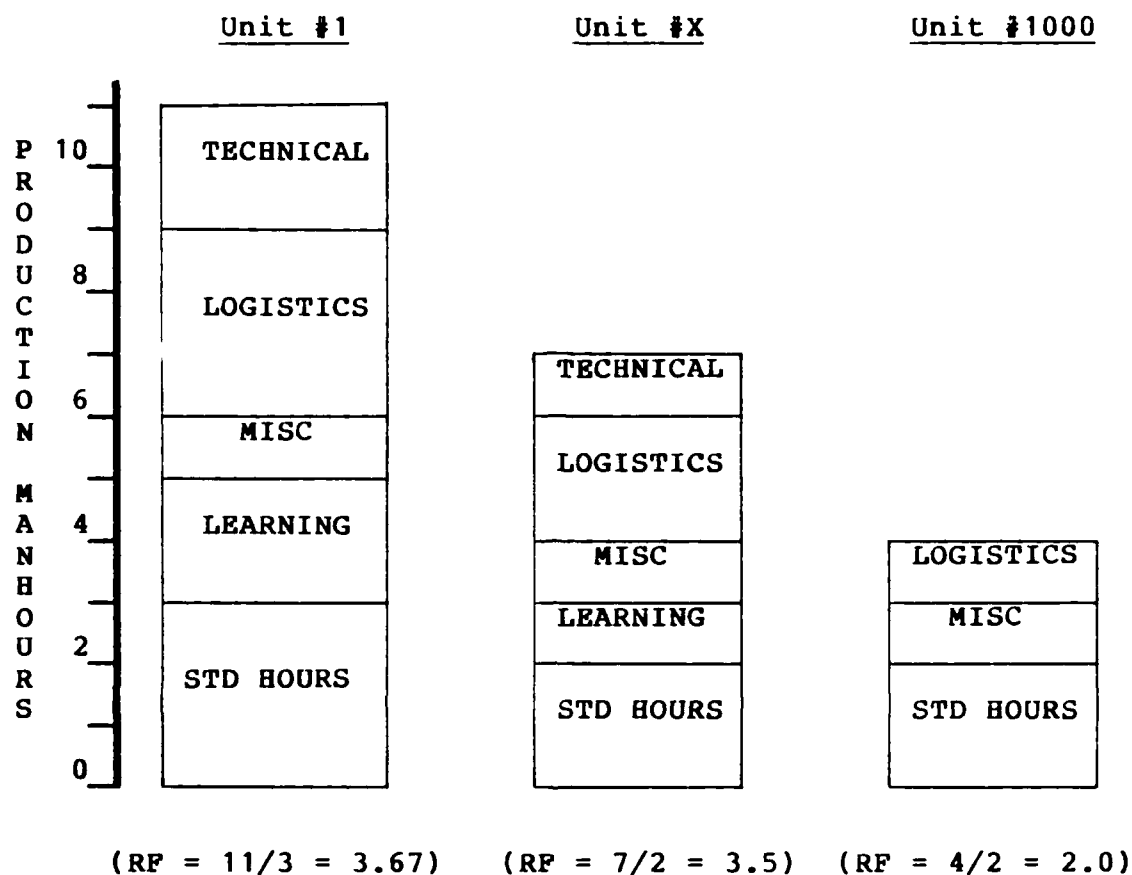


Figure 5. Sample Categories of Realization Factor Elements Throughout a Production Program (Per Unit) [18:4]

Elements of a technical nature include manufacturing coordination, engineering design changes, fit problems, design errors, operation sheet errors, tooling errors, sequence errors, and engineering liaison coordination. Logistical elements of variance that add to the realization factor are incorrect hardware, part shortages, waiting for



an inspector and scrap, rework and repair (SRR). There are miscellaneous elements that cannot be controlled such as the weather, excessive overtime and excessive fatigue. The last category that contributes to the realization factor for unit number one is learning. The elements of learning include worker familiarization, instruction, blue print reading and operation sheet reading [18:4].

A contractor's production operations at unit "X" should be more efficient than at unit number one due to improvements across all areas that make up the realization factor. Still, inefficiencies exist and should be the focus of continued tracking, analysis and improvement. Elements of technical inefficiency include design, process or method changes. Elements of logistical inefficiency include parts shortages, waiting for inspections and scrap, rework and repair (SRR). Weather delays, excessive fatigue and excessive overtime are miscellaneous elements that must be accounted for, and in part, may be tied to management actions. Learning elements also continue to contribute to the build up of the realization factor especially with a program that experiences many changes. Workers having to frequently check operation sheets and instructions make up the biggest part of this category [18:4].

Typically, when production reaches unit 1000 in the defense aerospace industry, there remain some inefficiencies that are difficult to remove from operations. When a

contractor achieves unit 1000 production, theoretically there should be no inefficiencies remaining in the operations (note also that unit 1000 is an average assumption, not an absolute "magic" number). However, industry has recognized that there are logistical and miscellaneous elements of variance that occur and cannot be totally controlled. The 1986 Air Force Systems Command (AFSC) survey reported that scrap, rework and repair (SRR) are the main logistical problems, and weather delays and excessive fatigue are the primary miscellaneous elements that keep the contractor from reaching 100 percent efficiency [32:7].

If the contractor's variance analysis program is working as it should, then unreasonable or inefficient variances are identified and reduced throughout the program. The 1986 AFSC survey revealed that defense companies believe that the major inhibitors to meeting standard are engineering changes, material delays or shortages, machine or tooling problems, and rework [32:7]. Yet, the defense contractors surveyed also reported that the most frequently tracked labor variance elements are worker performance, worker caused rework, and engineering changes. This is somewhat of a "disconnect" because it appears that what is being tracked the most is not what is considered by defense contractors to be the major inhibitor to meeting standard. The survey concluded: "This may be due to earlier industrial

engineering emphasis on using work measurement programs to make workers work harder" [32:7].

Air Force Systems Command (AFSC) policy makers believe that many defense contractor work measurement systems (and the labor hour collection systems which feed them) have not been modernized to permit collection, analysis and improvement of non-worker caused problems. Thus, the report summary stated: "More emphasis must be directed towards variance analysis and associated corrective action in order to affect productivity improvements" [32:7].

The contractor's work measurement system should track the elements of variance by category and identify both adverse and positive influences. The cause and effect relationships should then be identified and quantified. Contractors propose realization factors based on past performance. However, if defense contractors have, in fact, not been using their systems to the extent possible, as it seems, then further progress needs to be made to comply with recent legislation and DoD policy. The AFSC survey summary stated in response to this finding: "In particular, variance analysis and reduction, methods improvement, and the willingness to use work measurement visibility to improve pricing and negotiating appear to require more emphasis" [32:8].

At an Air Force Contract Management Division (AFCMD) seminar on 6 May 1987, Mr. Sydney Pope of HQ AFSC presented

AFSC policy regarding the use of labor standards in pricing and negotiating defense contractors' proposals. This policy states that Air Force Systems Command representatives should analyze the proposed variance from standard and any associated trends by categories of elements whenever the data are available.

Evaluation of variances includes trend analysis of each variance category. The non-recurring and non-productive elements that may distort the trends must be removed and the anticipated effects of process or methods improvements should be quantified. Such improvements may stem from MANTECH, TECHMOD or Value Engineering projects. It is helpful to then analyze each category of variance from standard separately, rather than as one lump sum, so that visibility into the variance trends can be maintained.

To quantify these trends may require complicated mathematical techniques such as linear and multivariate regression analyses, exponential smoothing, and time series analysis. A discussion of these techniques is outside the scope of this thesis and may be the subject of the Air Force Contract Management Division training course now in progress [43].

Once the trends are quantified by category they are combined with standard labor to arrive at a more realistic and efficient realization factor (or performance index). The factor is then multiplied by the proposed standard time

to calculate the government's estimate of the total direct manufacturing labor hours required to complete the contract, as shown by Figure 6 [46].

Standard Time	X	Adjusted Realization Factor	=	Total Direct Manufacturing Labor Hours
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Figure 6. Build-Up of Direct Manufacturing Labor Hours

The government analyst then calculates the direct manufacturing labor cost by multiplying the manufacturing labor hours by the base hourly rate, as shown in Figure 7.

Direct Manufacturing Labor Hours	X	Base Hourly Rate	=	Direct Manufacturing Labor Cost
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Figure 7. Build-Up of Direct Manufacturing Labor Costs

On most production contracts, the proposed direct factory labor cost is the basis for calculating factory overhead, certain other direct charges, and usually a large portion of general and administrative expenses. With a more reasonable base, the ultimate price charged to the Government should be considerably less than it otherwise would have been [47].

## 2. Application Example.

Air Force Systems Command (AFSC) has developed an example of how government representatives should use data from a contractor's work measurement system to price contracts. This example demonstrates what the data should look like and what it can tell the analyst. Mr. Sydney Pope, Manufacturing Staff Officer at AFSC, developed this example from actual defense contractor data. Mr. Charles M. Hooper, Director of Manufacturing at Air Force Systems Command, then presented this case to the Aeronautical Systems Division Pricing Symposium on 17 June 1987. The contractual data item (DI-MISC-80295) that was written by AFSC, and approved by all the services, will promote consistency in labor performance reporting and is the key to more consistent analysis of defense contractor proposals by government representatives. Mr. Pope stated that it would probably take several years before widespread acceptance of the contractual data item by defense contractors leads to consistent use by the Government of work measurement data to price/negotiate contracts [47].

The objectives of the data item requirement as stated by Mr. Sydney Pope are: 1) to provide deliverable data that will permit progress trend analysis, support government acquisition reviews, and permit government contract administration personnel to monitor program progress; 2) to assure contractor accountability; and 3) to promote

consistent interpretation of data by government representatives. The basic requirements as specified by the data item are detailed reports of Type I coverage of direct labor hours, quantity of units expected, quantity of units completed, standard hour content per unit, total actual manufacturing hours, actual manufacturing hours worked on standard, total earned standard hours, and a performance index (realization factor). [46]

Figure 8 shows the fluctuations of the standard base and actual manufacturing labor hours per unit for a defense acquisition from the first quarter of 1982 through the fourth quarter of 1985. The graph of actual hours shows that starting with the first unit, improvements in the number of hours required per unit have not been consistent. Without further data, the reasons for these fluctuations would not be evident to the government price/cost analyst. An analysis of the elements of standard labor (normal time, PF&D, and special allowances) revealed that the standard base fluctuations were due to engineering design or manufacturing resource changes as well as process or method improvements. The fluctuations of performance (variance from standard) were broken into categories with the non-recurring elements removed to determine a reasonable trend for each category in order to forecast future performance [46].

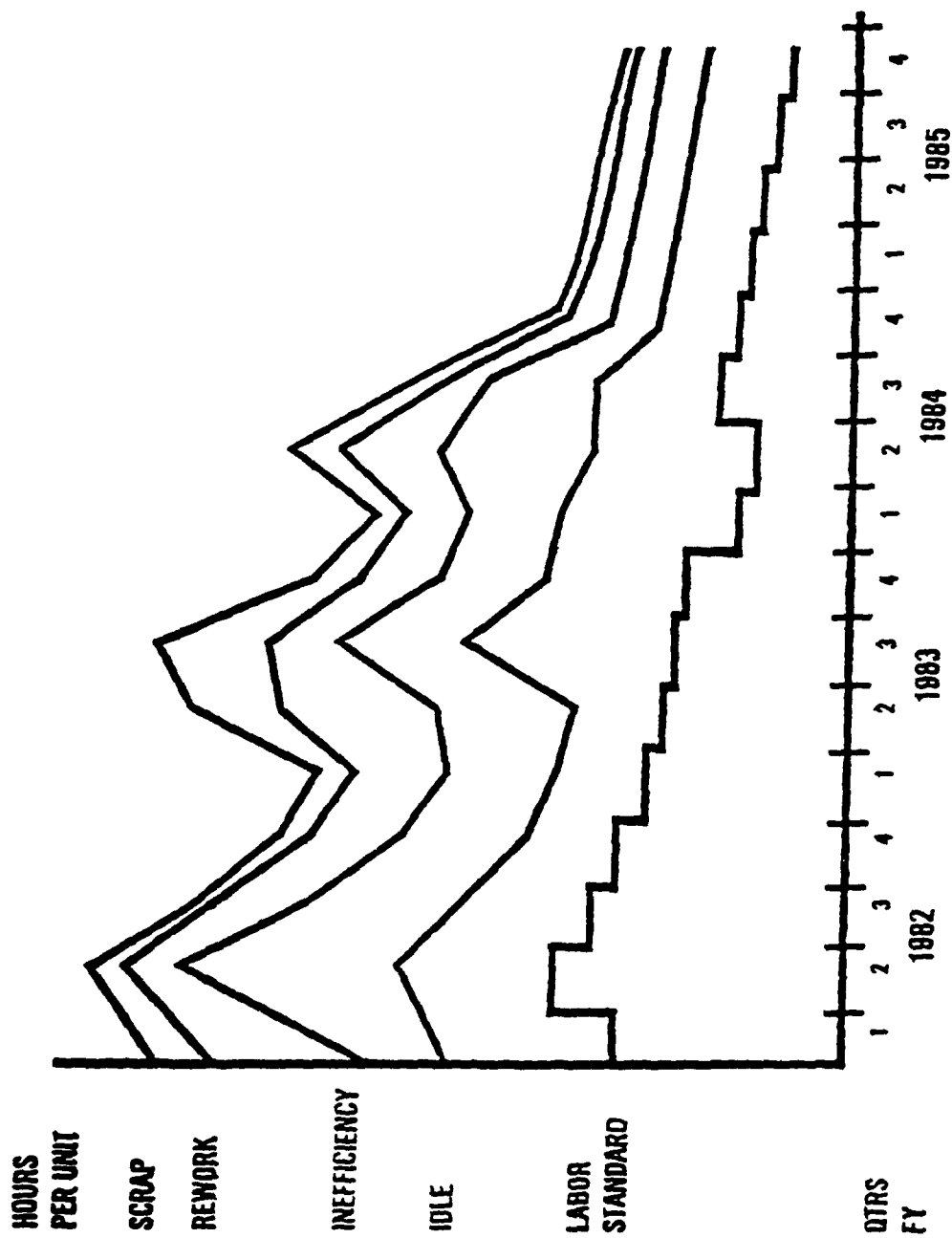


Figure 8. Sample Defense Program Labor Hour Fluctuations [37]



Figure 9 shows the hours per unit for the first year of production with the elements of variance broken out by category. This contractor tracked the non-productive performance elements according to scrap, rework, idle time or general inefficiency categories. With an unstable product design, start-up problems caused an increase in production time, called a performance spike.

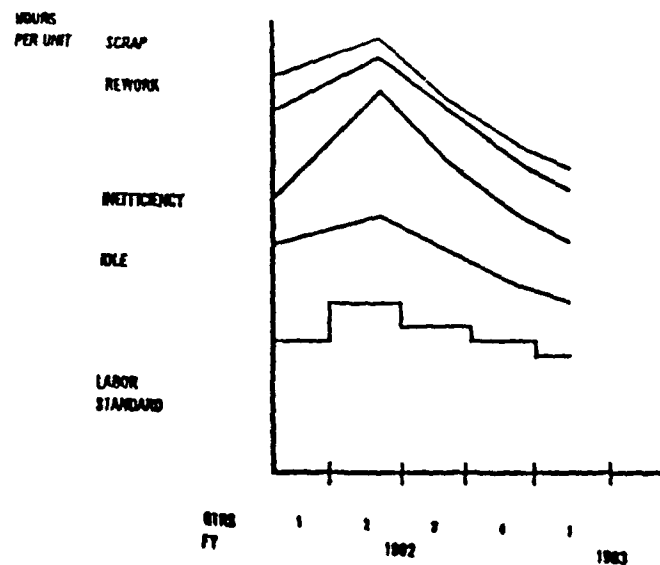


Figure 9. First Year Labor Hour Content [46]

An examination of the standard hour content revealed that additional operations had been added to satisfy new design requirements. Once the design stabilized, producibility efforts improved the processes which allowed the standard hour content to drop. As the design further stabilized, technical and logistical issues were solved and worker learning began to bring the number of hours per unit steadily down as seen in quarters three and four of 1982 [46].

Figure 10 shows the fluctuations of production performance in 1983. The elements of variance increased even as constant methods improvements lowered the standard base labor content. The rise in variance from standard was the result of inadequate in-process quality inspections that led to inefficient operations and excessive scrap and rework. Once these problems were solved, performance once again began to improve steadily [46]. Note the visibility that variance analysis gives the contractor into problems and corrective actions.

The last period of data covered the first three quarters of 1984 and is shown in Figure 11. The data showed that performance improvements continued until some old piece of equipment broke down. Before it could be replaced, certain details of the operations had to be temporarily subcontracted to a new, inexperienced vendor.

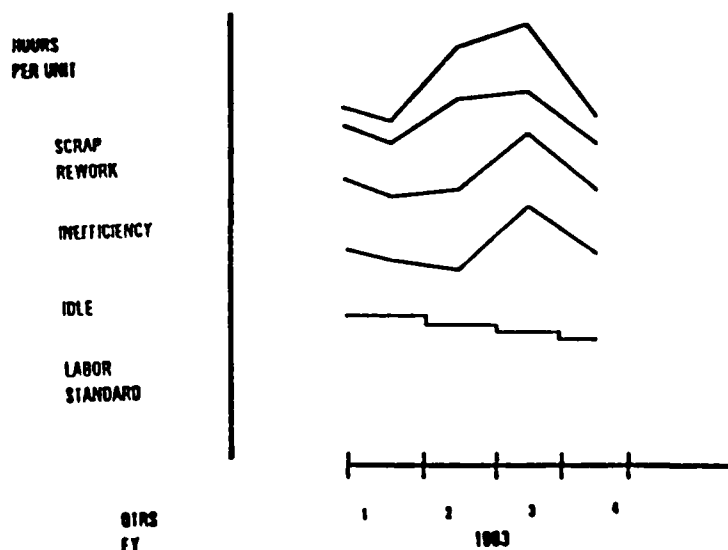


Figure 10. Second Year Labor Hour Content [46]

This explains the sudden drop in standard hours since those operations were no longer being completed by the prime contractor. With the new vendor handling part of the operations, in-process material flow was interrupted by inferior materials from the subcontractor. However, once a new, more productive machine was working, the subcontract was terminated. With more productive operations, the standard hour content (SHC) was reduced to a level below that for operations using the old machine. The variance from standard then showed steady improvement, as well, from the end of 1984 through 1985 [46].

Having identified and quantified the non-recurring and unproductive factors, the government price/cost analyst eliminated them from the performance data. The recurring and productive elements, as well as the standard hour content, were then quantified using regression analysis. A trend was determined for each separate and distinct element of the performance data, including the standard hour content. The resultant trends are shown in Figure 12. The individual trends were then summed to give an overall trend for unit production. From this, a more reasonable realization factor was calculated (the sum of variance elements and the standard hour content divided by the standard hour content).

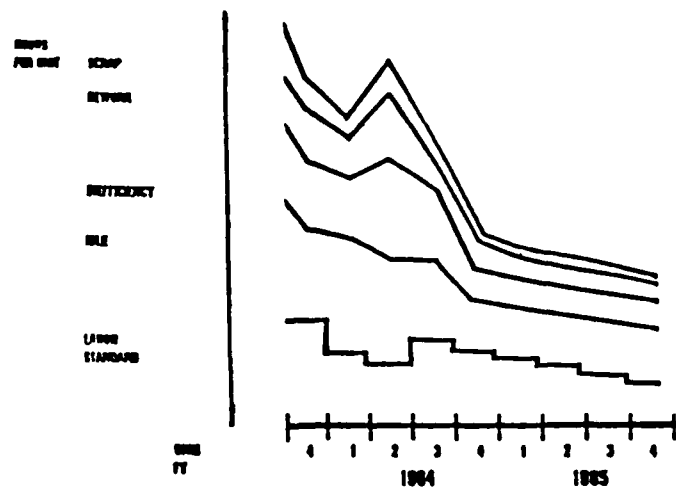


Figure 11. Third Year Labor Hour Content [46]

The realization factor was applied to the proposed manufacturing labor hours to estimate the total manufacturing labor performance required on the contract under negotiation [46]. This provided the manufacturing labor base to which manufacturing and other overhead expenses were then added.

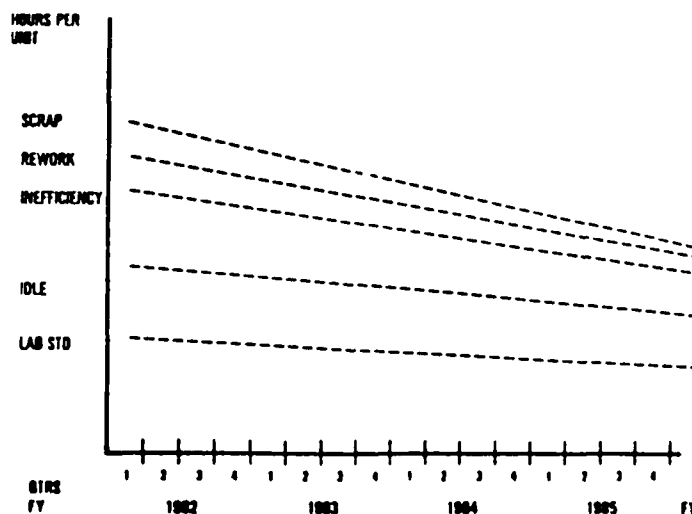


Figure 12. Trend Analysis of Labor Standards and Variance [46]

## V. Issues

The Air Force Systems Command (AFSC) policy of using work measurement data when available to price and negotiate contracts has been slow to implement. This technique is new to many AFSC pricing personnel with training now being conducted for the first time on a short-term basis. But the availability of useable data has also been a problem. The AFSC survey of defense and commercial companies' work measurement (WM) programs, released September 1986, concluded that defense contractors have the elements in place for effective work measurement systems -- accurate labor standards and regularly scheduled audits to confirm data collection procedures [33]. However, the extent to which management has used this data to manage performance is questionable. In particular, AFSC stated that variance analysis and reduction, methods improvements, and the willingness to use work measurement visibility to improve pricing and negotiating require more emphasis [32:8].

Defense contractors have lobbied against legislation and resisted DoD policy regarding MIL-STD-1567A and the use of work measurement data to price and negotiate contracts since 1975 when MIL-STD-1567 (USAF) was first released. A number of the issues surrounding the use of WM data in pricing/negotiating contracts were discussed at the 1986 Aeronautical Systems Division (ASD) Pricing Symposium. The issues remain unresolved today.

A. Issue #1

Mr. Charles M. Hooper, Director of Manufacturing at AFSC, presented the Government's point of view on these issues at the 1986 ASD Pricing Symposium. The first questions addressed were, "Why does the Government focus so much attention on direct manufacturing labor when it is typically a small percentage of the total cost and growing smaller? DoD productivity programs such as TECHMOD aim at reducing or eliminating direct manufacturing labor so why bother with this effort?" To address this issue of decreasing manufacturing labor content, Mr. Hooper discussed several observed trends of the aerospace industry. First, Figure 13 shows that despite such efforts as TECHMOD to reduce the manufacturing labor content, as a percentage of sales, it has remained nearly constant [36].

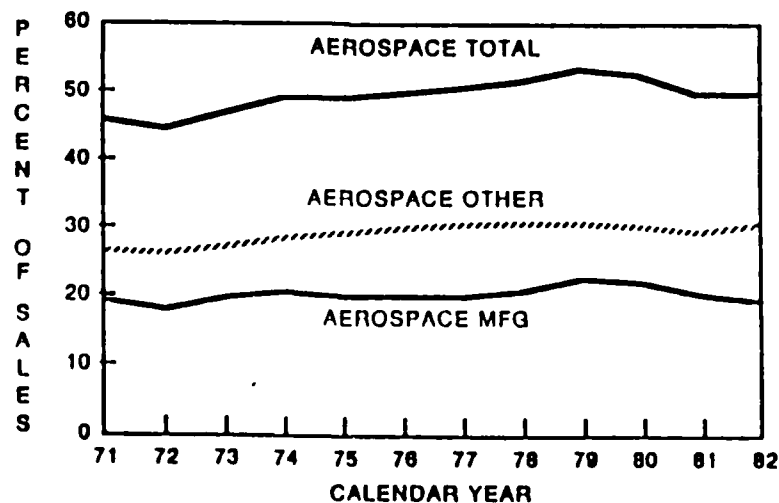


Figure 13. Aerospace Payroll as % of Sales

Figure 14 shows the breakdown of sales per worker. The trends indicate that the aerospace industry has not kept pace with the productivity improvements of U.S. manufacturers in the general economy [36].

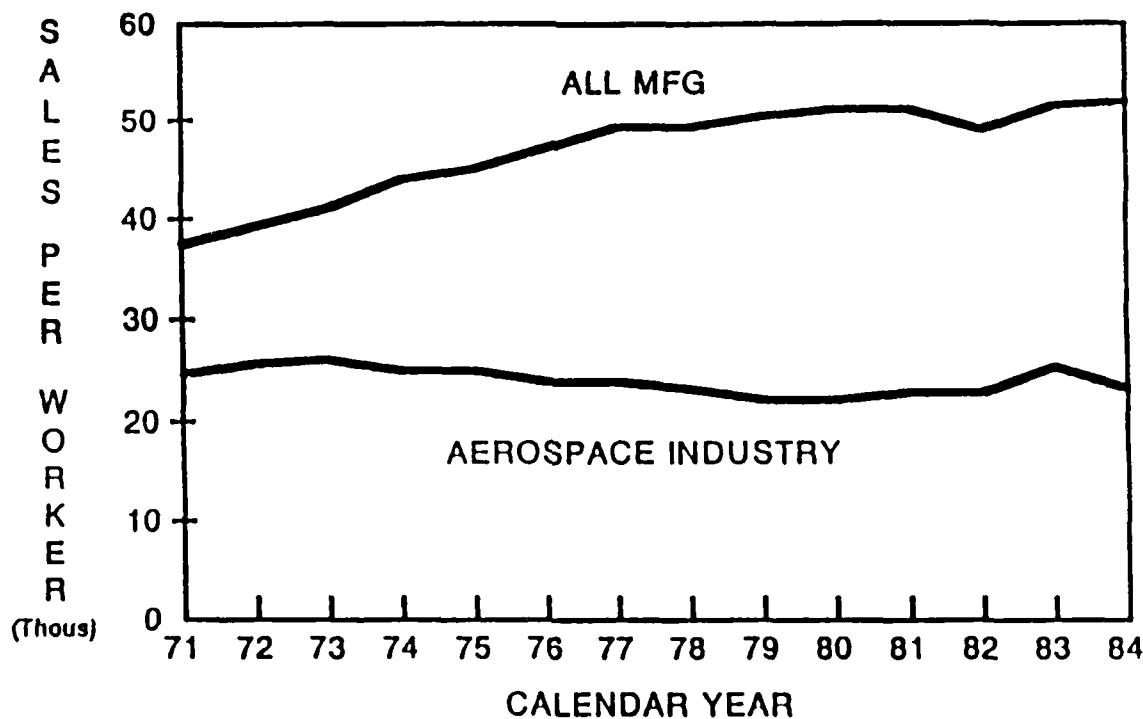


Figure 14. Sales per Worker [36]

The capital investment expenditures by the aerospace industry as a percent of sales have lagged the U.S. average for all manufacturers as well as that of durable goods expenditures as shown by Figure 15 [36]. The graph does, however, indicate a general trend upward of expenditures by the defense industry with investment in capital actually exceeding those of the industries in the late seventies.

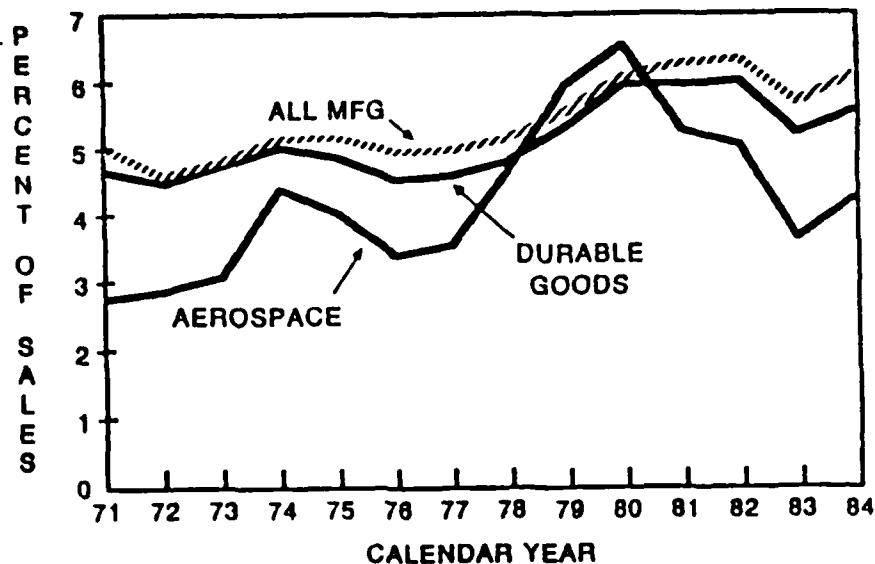


Figure 15. Capital Investment as % of Sales [36]

The trend of capital investment as a percentage of assets for the aerospace industry is shown in Figure 16. It indicates a general decline in expenditures as a percentage of assets [36].

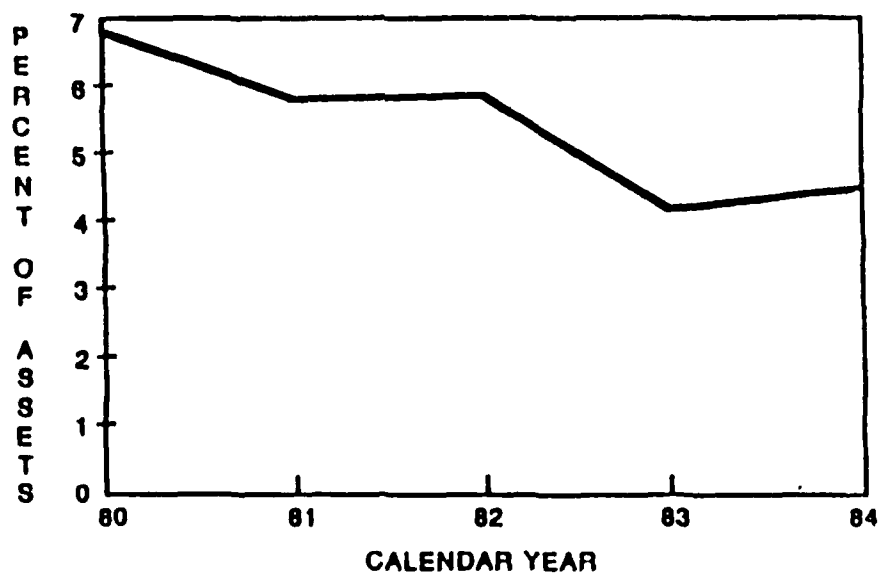


Figure 16. Capital Investment as % of Assets [36]



The 1986 Production Base Analysis report, published by the United States Air Force, examined the recent trends of different U.S. industries. The Executive Summary stated that the productivity trends of the defense aerospace industry, in general, still have not improved and are of concern [14:10]. But even if the aerospace industry were to increase productivity levels and decrease the direct manufacturing labor content significantly in the future, what would be the impact on Government policy concerning MIL-STD-1567A and the use of labor standards to price/negotiate defense contracts?

This question was addressed by Mr. Hooper, at the 1986 ASD Pricing Symposium, using an example that illustrates how costs are typically built-up and why it would still make sense for the Government to focus on even a small percent of the total cost of a program [36]. Figure 17 shows the build-up of cost for a program similar to the example previously discussed in Chapter IV.

TOUCH LABOR	- \$ 20
DIRECT SUPPORT - $1.5 \times 20$	- \$ 30
OVERHEAD - $2.0 \times (30+20)$	- \$100
MATERIAL	<u>- \$100</u>
TOTAL PROGRAM COST	- \$250

TOUCH LABOR = 8% OF PROGRAM COST

Figure 17. Cost Build-Up Example [36]

Manufacturing touch labor accounts for 8 percent of the total program cost. If the touch labor content is overstated by 20 percent then it would appear that the resulting overstated program cost would be just 1.6 percent ( $8\% \times 20\% = 1.6\%$ ). But because costs are typically built-up using manufacturing direct labor as a base, any overstatements (or understatements) of the labor required, will be multiplied [36], as was previously discussed in Chapter IV. Figure 18 further illustrates the actual costs of overstated labor on a sample program.

TOUCH LABOR = \$20	20% OVERSTATED = \$24
DIRECT SUPPORT = $1.5 \times 20 = \$30$	$1.5 \times 24 = \$36$
OVERHEAD = $2.0 \times (30+20) = \$100$	$2.0 \times (36+24) = \$120$
MATERIAL = \$100	MATERIAL = \$100
TOTAL PROGRAM COST = \$250	TOTAL PROGRAM COST = \$280
TOUCH LABOR = 8% OF PROGRAM COST	CHANGE IN PROGRAM COST
	$\frac{280-250}{250} = 12\%$
	NOT 1.6%

Figure 18. Actual Overstatement of Cost [36]

As shown, the resulting program overstatement would be 12 percent rather than the "piddling" 1.6 percent assumed. Although it should be obvious that relatively small increases in direct labor base hours can significantly increase the "bottom line" costs, there are still differing viewpoints among both government and contractor personnel [47]. If the program costs are in the tens or hundreds of

millions of dollars, as many defense programs typically are, then the resultant overstatement will certainly be no "piddling" sum [36].

Effective work measurement programs identify and correct these overstatements throughout production. Until some other element of cost (such as machine hours or some type of cost estimating relationship) is used as a basis for applying other program costs, direct manufacturing labor hours will continue to hold substantial leverage in terms of return on analysis by government representatives.

B. Issue #2

Another issue concerns defense contractors' use of improvement (or learning) curves in conjunction with labor standards to manage, price and negotiate contracts. According to the AFSC work measurement survey released in September 1986, most defense contractors use labor standards to estimate, schedule and budget. But, the variance analysis and reduction programs are not used effectively [32:8]. Instead historical actuals are applied using improvement curves. Therefore, the cost estimates, schedules, and budgets still may not represent the most efficient manufacturing capabilities possible. It appears that contractors are using the amount of standard hours and an historical improvement curve to set and allocate the budget. Once the budget has been negotiated, reduction below

the budget curve is unusual [2:9]. As discussed earlier, it is the use of historical improvement curves that may project previous inefficiencies into future cost estimates.

This method of contractor management was discussed at the 1986 ASD Pricing Symposium and described as a "self-fulfilling prophecy" [36]. Historical performance (actual costs) are translated into trends or improvement curves which are used to build the estimate. The estimate, in turn, becomes the budget, which then becomes the performance goal [36].

Figure 19 illustrates this "self-fulfilling prophecy". As the program proceeds through production, actual costs are compared to what has been budgeted rather than to the standard. This variance is tracked quite extensively using programs such as Cost/Schedule Control Systems Criteria (C/SCSC).

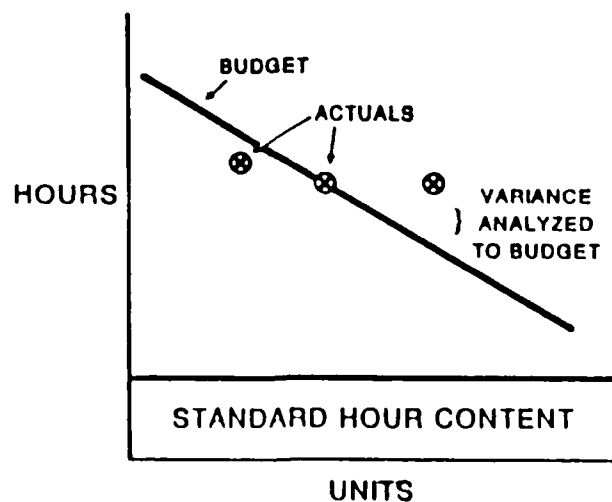


Figure 19. Labor Performance Tracked to Budget [36]

If the contractor is in conformance with MIL-STD-1567A then the true variance that should be identified and tracked is that which is over and above standard. An example of this is shown in Figure 20, below. If these variances are analyzed and corrected over the life of a program, more efficient contractor operation should result [36]. Therefore, continued Government emphasis on aggressive variance analysis and reduction, methods improvement, and the use of work measurement visibility to improve pricing and negotiating should probably be expected until defense contractors demonstrate the willingness and commitment to doing these things themselves.

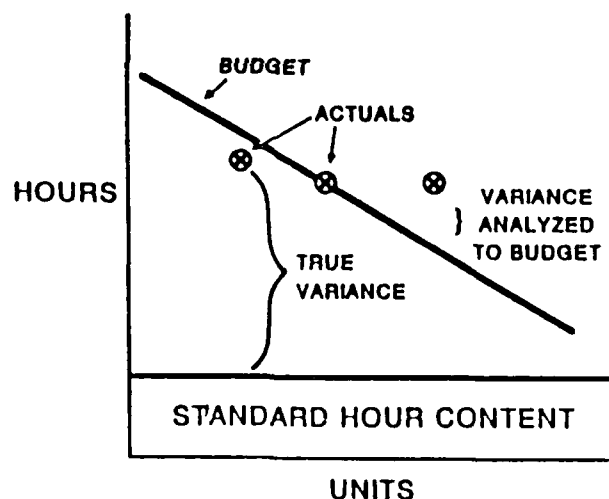


Figure 20. Labor Performance Variance from Standard [36]

C. Issue #3

Still widely debated is the issue of costs versus benefits of tracking and reporting labor performance data as required by Government legislation and policies. In 1980, the Government Accounting Office (GAO) examined this question and concluded that, at the time, MIL-STD-1567 (USAF) requirements were indeed cost effective. The report concluded that "dramatic" productivity improvements and cost savings were realized at contractor plants where the standard had been applied [51:5].

Government contract administration personnel were quoted as stating in that report that it actually made administration of contracts simpler and less costly because it was compatible with existing management systems and not redundant [19]. Mr. Arif Mir, Manufacturing Staff Officer at Air Force Contracts Management Division (AFCMD), stated that the just released contractual data covering labor performance reporting will standardize data and enable Government representatives to better perform a Should Cost analysis as well as monitor contractor performance. The number of personnel and time required to perform a Should Cost analysis should also drop [43].

The 1986 AFSC Work Measurement survey assessed the administrative costs to contractors of maintaining programs as required by MIL-STD-1567A. The defense contractors reported significant industrial engineering (i.e., 8 to 23

hours) time to develop one Type I standard hour. AFSC concluded that this was misleading though because those requirements were based on developing "unique" standards and very few standards are totally "unique" [32:7].

The survey further reported that contractors claimed that more than 75 percent of the hours required to maintain standards are the result of methods and process improvements as well as design and material changes. AFSC concluded, however, that "these costs appear to be a normal cost of staying in business -- and may not be appropriate as additional costs required by the imposition of MIL-STD-1567A" [32:8].

The survey reported an approximate average annual cost to implement and maintain a work measurement system of \$3 million. The potential benefits as listed by the survey are:

- a. Reduced standard hour content (SHC) of about 15 percent when upgrading Type II to Type I standards.
- b. Reduced SHC of 12 percent in full-scale development (FSD), 9 percent in early production, and 6 percent in mature production: with cumulative SHC reduction over the life of the program nearly 27 percent resulting from methods improvements. A corresponding decrease in actual touch labor hours can also be anticipated.
- c. Increased productivity. First, workers know what is expected of them and their goals are both challenging and attainable. Second, there is the potential for meaningful corrective actions due to increased emphasis on reducing management caused variances.

- d. Better, more objective data for estimating, budgeting, scheduling, and analysis of variance (whether worker or management caused) [32:7].

D. Issue #4

The last major issue identified in this research concerns supplying the Congress with defense contractor work measurement data. When Congress debated the MX-missile in March 1984, Senator Charles E. Grassley, R-Iowa, tied his vote to a committee request for detailed contractor work measurement and cost data for the missile. The data did not arrive in time and Grassley voted "no" [25:1283]. Recent legislation and DoD policy ensures that these data are now available whenever requested by Congressional members. However, other problems have begun to surface which raise serious questions about supplying this data to Congress.

There are several reasons why meaningful comparisons of contractors' work measurement data are risky. First, although a defense contractor's work measurement system may meet the requirements of MIL-STD-1567A, there is enough flexibility in the Standard such that significant differences may exist between the labor standards used and the resulting performance data. This is due to the differing techniques and definitions used by each contractor to establish labor time standards and report data. MIL-STD-1567A provides broad criteria which the contractor's work measurement system should meet but does not eliminate the



differences between between systems [2:10]. Therefore, direct comparison of defense contractor work measurement data may be meaningless.

Another point of caution surrounding this data involves the interpretation of a contractor's performance index (or realization factor). In a presentation to the Air Force Contract Management Division (AFCMD) Seminar, 6 May 1987, Mr. Sydney Pope of AFSC gave an example demonstrating the riskiness of interpreting a contractor's performance index trend. Figure 21 shows the performance to standard for an unidentified defense program [46].

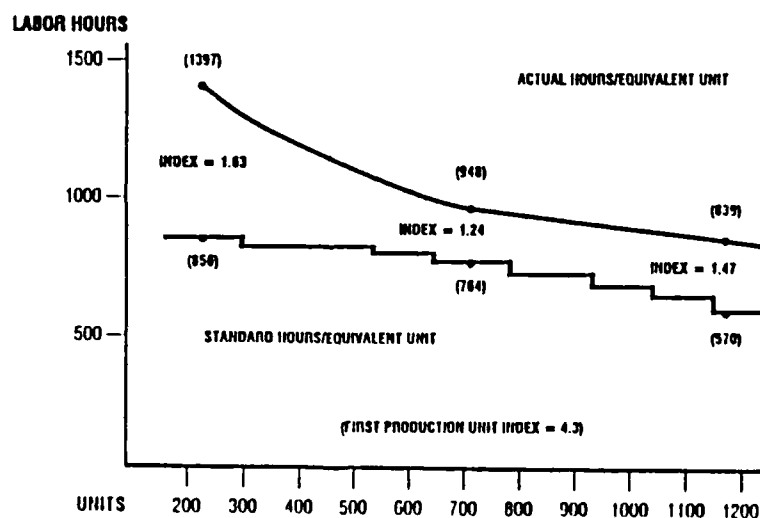


Figure 21. Sample Defense Contractor Performance Indices [46]

Early in the production cycle of a particular defense program, the contractor's performance index (ratio of "actual" to "standard" hours or realization factor) was 1.63. The performance index was reduced to 1.24 one year

later. However, the following year, the performance index had increased to 1.47 [46]. It should be noted that work measurement and unit cost data is volume dependent rather than time dependent. Therefore, without a better understanding of the data it would appear that program performance had declined.

Although the performance index had indeed increased between the end of the first quarter of FY84 and the end of the first quarter of FY85, the "actual" manufacturing hours required to produce a unit had actually declined from 948 to 939 direct manufacturing labor hours. The contractor had undertaken an effort to eliminate manufacturing touch labor hours by implementing more efficient methods and processes [2:12]. So, despite a higher performance index, the cost to the Government was less.

An emphasis solely on the performance index without a knowledge of the underlying causes can lead to incorrect conclusions about a contractor's efforts. This could constrain investments by contractors which might result in temporary inefficiencies until processes or methods are proven.

One last note of caution concerns the fear by defense contractors that proprietary data may be released by Congress to competitors. As contractors are required to submit more and more cost and pricing data the chances that this data may be released to the public in some way have

increased as well. This topic is worthy of further research as data becomes available.

E. Summary of Issues

A work measurement system is an excellent management tool and can be used to reduce the cost of defense weapon systems. However, the research indicates that labor standards still are not used uniformly to price and negotiate contracts and that the values and techniques are not fully understood. This explains perhaps why some of these issues continue to be debated by both government and defense industry personnel. There also appear to be some potentially valid reasons against supplying contractor work measurement data to Congress.

## VI. Conclusions and Recommendations

### A. Conclusions

The Should Cost approach to estimating future costs has proven to be an effective substitute for competition on sole-source acquisitions. However, the additional manpower required has not always been available. An alternate means of achieving the benefits of a Should Cost analysis is to take advantage of established work measurement programs, including a well-monitored variance analysis program. This approach has a distinct advantage over the more traditional approach of using past cost trends to forecast future production costs. By analyzing a contractor's labor performance data, the inefficient and unnecessary costs may be identified and removed before trends are applied to proposed production hours. The resulting estimate of required manufacturing labor should lead to more reasonable and efficient negotiation and budgeting objectives. The final result should be lower defense system costs and improved defense industry productivity.

The Air Force has led the DoD in encouraging more effective defense contractor work measurement systems and the use of labor standards to price and negotiate contracts. Support from the other services was lacking until the Joint Logistics Commanders (JLC) recognized the need for

interservice support of MIL-STD-1567A in 1985. This action should lead to wider and more consistent application.

The Air Force System Command (AFSC) survey report, published in September 1986, showed the extent to which defense contractors with MIL-STD-1567A on contract and commercial companies (lacking any Government work measurement requirement) have implemented and maintained work measurement systems. Although most defense companies use labor standard information to estimate costs, many do not identify and quantify realization factor elements. Those factors which are tracked are often limited to "operator" rather than "factory" elements, which are the responsibility of management, despite the recognition of the impact of these "management" responsibilities on costs and productivity [33].

AFSC policy states that work measurement data, when available, must be used by both the contractor and Government representatives to price and negotiate defense contracts. Yet, recent AFSC reviews indicate that although MIL-STD-1567A has been successfully applied to many AFSC contracts, AFSC has been less than successful in using contractor labor performance data to price and negotiate [33]. This is due, in-part, because the value and techniques of applying work measurement data to the pricing and negotiation of contracts are not fully understood and because many government pricing personnel require training

on the concepts of work measurement and the use of labor performance data in pricing contracts.

AFSC has initiated a training course to instruct key pricing personnel at the field offices and product divisions. Only the courses planned for late FY87 have been funded to date. If funding is approved, courses will be conducted throughout FY88 as well. However, the instruction of personnel after FY88 has not yet been addressed. With greater acceptance and use of labor standards to price and negotiate contracts, in the future, there will also be an increasing need for this training. Therefore, a block of instruction is needed in any basic pricing courses sponsored by the service schools. Instruction in the more advanced concepts of work measurement and application techniques of pricing with labor standards is also needed at the intermediate and advanced training course level.

Debate continues on several issues concerning the use of labor standards and the submission of data by contractors. Contractor and government personnel continue to question the attention given to manufacturing labor costs, citing DoD and contractor efforts to reduce direct labor costs as a percentage of a programs total cost. However, recent trends indicate this has not happened. In fact, direct manufacturing labor costs are still used as a basis for calculating other contract costs by a majority of contractors. Therefore, until another basis for determining

total contract costs is used by contractors, focus on manufacturing touch labor hours continues to hold the greatest leverage in terms of return on analysis.

Another issue of continued debate is the costs versus the benefits of implementing and maintaining an effective work measurement system. A recent AFSC survey of defense and commercial companies examined this point and concluded that some of the industry claims were misleading. Therefore, further research in the area of the costs versus the benefits is probably required.

The submission of work measurement data to Congress also is a topic of continued debate and concern. Contractors fear this data may be misinterpreted by some members of Congress or released to competitors. Since many work measurement systems are considered proprietary, a release of this data could diminish a contractor's competitive edge. This would defeat the purpose for which the data are reported in the first place, improving productivity and reducing costs.

#### B. Recommendations

The following areas are recommendations for further study or action:

1. Because the value and techniques of using labor standards are not widely understood and are new to many government pricing personnel, a block of instruction should be added to all basic pricing courses sponsored by the service schools. There should also be an intermediate or advanced training course established to teach the concepts of work measurement and the application techniques of pricing defense contracts with labor standards.

2. An objective examination of the costs versus the benefits of MIL-STD-1567A and the reporting of labor performance data to the Government (especially to Congress) should be conducted after further implementation of MIL-STD-1567A by all the services. An examination of any possible compromises of proprietary data should be included. An examination of the impact of recent legislation, policies, and requirements (such as the new contractual data item) on contract administrative personnel is also recommended as data become available in the next few years.

3. AFSC has led the DoD in encouraging effective contractor work measurement systems and the use of labor standards to price and negotiate contracts. A comparison of each of the service's approaches and policies could lead to more consistent and widespread DoD application of MIL-STD-1567A and the use of labor standards in pricing and negotiating contracts.



## Appendix A

### INTERVIEW GUIDE

- What is the background of Government legislation and policies requiring the use of labor standards in pricing/negotiating defense system contracts?
- How are labor standards used to price defense systems acquisitions?
- What are the advantages of using labor standards to estimate costs as compared to more traditional methods?
- What are the limitations of this technique?
- What are the key issues surrounding the application of labor standards in pricing defense systems contracts?
- Is training for cost and pricing personnel available and adequate?

## Appendix B

### DEFINITIONS

The following definitions were taken from MIL-STD-1567A except as noted.

Actual Hours - An amount determined on the basis of time incurred to perform a task as distinguished from the forecasted time. Includes standard time properly adjusted for applicable variance.

Cost/Schedule Control Systems Criteria (C/SCSC) - A management tool used to compare actual costs with budgets and to track progress against schedules for defense contracts [13].

Earned Hours - The time in standard hours credited to a worker or group of workers for successfully completing a given task or group of tasks: usually calculated by summing the products of applicable standard times multiplied by the completed work units.

Element - A subdivision of the operation composed of a sequence of one or several basic motions and/or machine or process activities which is distinct, describable and measurable.

Labor Efficiency - The ratio of earned hours (the time it should have taken to perform the task) to actual hours spent on equivalent amounts of work during a reporting period. When earned hours equal actual hours, the efficiency equals 100%.

Learning/Improvement Curve - A plot of the price reduction of unit cost and/or the cumulative unit cost for an article as the quantity produced is increased [18].

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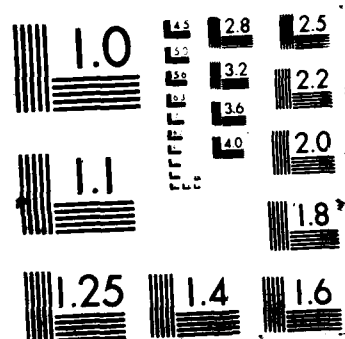
A COMPARISON OF TRADITIONAL METHODS VERSUS LABOR  
STANDARDS IN THE PRICING (U) AIR FORCE INST OF TECH  
WRIGHT-PATTERSON AFB OH SCHOOL OF SYST S A MARCY  
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Major Defense Acquisition Program - A DoD acquisition program that is not a highly sensitive classified program and is estimated to require an eventual total expenditure for research, development, test, evaluation of more than \$200,000,000 (FY80 constant dollars) or an eventual total expenditure for procurement of more than \$1,000,000,000 (FY80 constant dollars) [9].

Major System - A combination of elements that will function together to produce the capabilities needed to fulfill a mission need. The elements may include hardware, equipment, software or any combination thereof, but excludes construction or other improvements to real property. The DoD will designate a system as "major" when the total expenditures for a research, development, test, and evaluation are estimated to be more than \$75,000,000 (FY80 constant dollars) or an eventual total expenditure for procurement of more than \$300,000,000 (FY80 dollars) [9].

Manufacturing Technology (MANTECH) - A joint Air Force and defense industry initiative to develop new manufacturing technologies [14].

Methods Engineering - The analyses and design of work methods and systems, including technological selection of operations or processes, specification of equipment type, and location.

Normal (Leveled) Time - Normal (or leveled) time is the time required by a qualified worker, to perform a task at a normal pace, to complete an element, cycle or operation, using a prescribed method. The personal, fatigue and unavoidable delay (PF&D) allowance added to this normal time results in the standard time.

Operation - (1) A job or task consisting of one or more work elements, normally done essentially in one location; (2) The lowest level grouping of elemental times at which PF&D allowances are applied.

Operation Analysis - A study which encompasses all those procedures concerned with the design or improvement of production, the purpose of the operation or other operations, inspection requirements, materials used and the manner of handling material, setup, tool equipment, working conditions, and methods used.

Performance Factor - The ratio of operator hours required to build an acceptable unit to the standard hours earned [18].

Performance Index - The ratio of those total manufacturing hours required (standard plus variance) to build an acceptable unit to the standard hours earned (also called a realization factor) [18].

Personal, Fatigue, and Delay (PF&D) - Allowance built into a labor standard that accounts for unavoidable nonproductive time associated with performing the given task(s) [8].

Predetermined Time System - An organized body of information, procedures and techniques employed in the study and evaluation of manual work elements. The system is expressed in terms of the motions used, their general and specific nature, the conditions under which they occur, and their previously determined performance times.

Prime Contract - A contract directly between the Government and a defense company [9].

Realization Factor - (a) A ratio of total actual labor hours to the standard earned hours. (b) A factor by which labor standards are multiplied when developing actual/projected manhour requirements.

Should Cost - DoD review of a contractor's operations and facilities to estimate the cost of a defense system given the most efficient and productive capabilities of the contractor [6:238].

Standard Time Data - A compilation of all elements that are used for performing a given class of work with normal elemental time values for each element. The data are used as a basis for determining time standards for operations similar to those from which the data was taken.

Subcontract - A contract between the prime contractor and a third party to produce parts, components, or assemblies in accordance with the prime contractor's design, specification or directions and applicable only to the prime contract.

Technology Modernization (TECHMOD) - Also referred to as the Industrial Modernization Incentives Program (IMIP). A DoD initiative to modernize defense aerospace contractors through contractual incentives [14].

Touch Labor - Production labor which can be reasonably and consistently related directly to a unit of work being manufactured, processed, or tested. It involves work affecting the composition, condition, or production of a product; it may also be referred to as "hands-on labor", "factory labor", or "direct labor". NOTE: As used in MIL-STD-1567A, touch labor includes such functions as machining, welding, fabricating, setup, cleaning, painting, assembling, functional testing of production articles and that labor required to complete the manually-controlled process portion of the work cycle.

Touch Labor Standard - A standard time set on a touch labor operation.

Type I Engineered Labor Standards - These are standards established using a recognized technique such as time study, standard data, a recognized predetermined time system or a combination thereof to derive at least 90% of the normal time associated with the labor effort covered by the standard and meeting requirements of MIL-STD 1567A. Work sampling may be used to supplement or as a check on other more definitive techniques.

Type II Labor Standard - All labor standards not meeting the criteria of Type I Labor Standards. For example, an estimate of the time required for a process that is constantly changing.

Value Engineering - DoD initiative to share savings resulting from innovations to methods, processes, or other cost saving efforts after award of the contract [13].

Variance - That portion of touch labor related directly to a unit of work and not covered by standards. Includes those learning, logistics, technical, and other elements that make up the difference between actual hours incurred versus standard hours earned [18].



## Appendix C

### AIR FORCE SYSTEMS COMMAND POLICY ON

#### USE OF LABOR STANDARDS IN CONTRACT PRICING, NEGOTIATION, AND MANAGEMENT (AFSCR 550-8)

This regulation establishes the AFSC Commander's policy on the use of labor standards in contract pricing, negotiations, and management. It applies to HQ AFSC and AFSC activities.

1. Military Standard 1567A, Work Measurement, MIL-STD-1567A must be consistently applied to all major system acquisitions. When on contract, the provisions of the military standard must be fully complied with.

2. Use of Labor Standards:

a. Contractor Duties. When MIL-STD-1567A is on contract, contractors must be required to use labor standards, when available, consistent with recognized cost accounting methods, to develop budgets, plans and schedules; to form a basis for pricing and negotiations; and to baseline performance. "Actual" costs from earlier acquisitions cannot be accepted without careful scrutiny.

b. Government Duties. Whether MIL-STD-1567A is on contract or not, government representatives must use labor standards, when available, in a manner consistent with other recognized cost accounting methods, to plan, program, and budget acquisitions; negotiate contracts; and monitor subsequent contractor performance. If MIL-STD-1567A is not part of a contract, but the contractor has independently developed labor standard information, government representatives should ask for such information as part of the "fact finding" process. In this case, special contract clauses may have to be developed to allow the government to monitor contractor performance against labor standards.

3. Compliance with this Regulation. Program managers must make sure labor standards are used in pricing, negotiating, and managing contracts.

Source: Department of the Air Force. Use of Labor Standards in Contract Pricing, Negotiation, and Management. AFSCR 550-8. Washington: HQ AFSC, 30 April 1985.

## Appendix D

### SHOULD COST AMENDMENT

#### SECTION 915. SHOULD COST ANALYSES

- (a) **Report on Annual Plan.** - The Secretary of Defense shall submit to Congress an annual report setting forth the Secretary's plan for the performance during the next fiscal year of cost analyses for major defense acquisition programs for the purpose of determining how much the production of covered systems under such programs should cost. The report shall describe -
- (1) which covered systems the Secretary plans to apply such an analysis to;
  - (2) which covered systems the Secretary does not plan to apply such an analysis to and, in each such case, the reasons for not applying such an analysis; and
  - (3) which systems were determined not to be covered systems under a major defense acquisition program and the reasons for that determination.
- (b) **Covered Systems.** - For the purposes of subsection (a), a system under a major defense acquisition program shall be considered to be a covered system if -
- (1) a production contract for the system is to be awarded during the year using procedures other than full and open competition;
  - (2) initial production of the system has already taken place;
  - (3) the current plans for the DoD include production of substantial quantities of identical or similar items in fiscal years beyond the next fiscal year;
  - (4) the work to be performed under the contract is sufficiently defined to permit an effective analysis of what production of the system by the contractor should cost; and
  - (5) major changes in the program are unlikely.
- (c) **Submittal of Report.** - The report required by subsection (a) shall be submitted to the Committees on Armed Services of the Senate and the House of Representatives not later than the date on which the budget for the next fiscal year is submitted each year.

- (d) Definition. - The term "major defense acquisition program" has the meaning given such term in section 139a (a) (1) of title 10, United States Code.
- (e) Effective Date. - This section applies to covered systems for which initial production funds are first appropriated for a fiscal year after fiscal year 1986.

Source: U.S. Congress, Senate Conference Committee Report, Department of Defense Authorization Act, 1986. 99th Congress, 1st Session, Report 99-118, 29 July 1985.

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ABSTRACT

In recent years, reports by the media of cost overruns, overpriced spare parts, waste, and fraud have caused Congress and the public to doubt the ability of the DoD and the defense aerospace industry to control defense systems' costs. Valid or not, that perception has lead to statutory provisions that now require defense contractors to submit labor performance data, as well as cost and pricing data, with defense system proposals. Air Force Systems Command (AFSC) policy further requires the use of labor performance data, by both government and contractor personnel, to price and negotiate defense system contracts. Studies indicate that effective use of labor performance data, from a defense contractor's work measurement system, can result in more reasonable cost estimates, particularly in the case of sole source contracts.

The labor performance data referred to here is a part of what is commonly known as "work measurement". This study examined the evolving application of work measurement in the acquisition of major defense systems. The study investigated the value of work measurement programs and explored techniques for using labor performance data in pricing defense contracts. The study also compared this pricing technique with more traditional methods. As the implementation of this idea has stirred some controversy, the research also examines the issues that have arisen.

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